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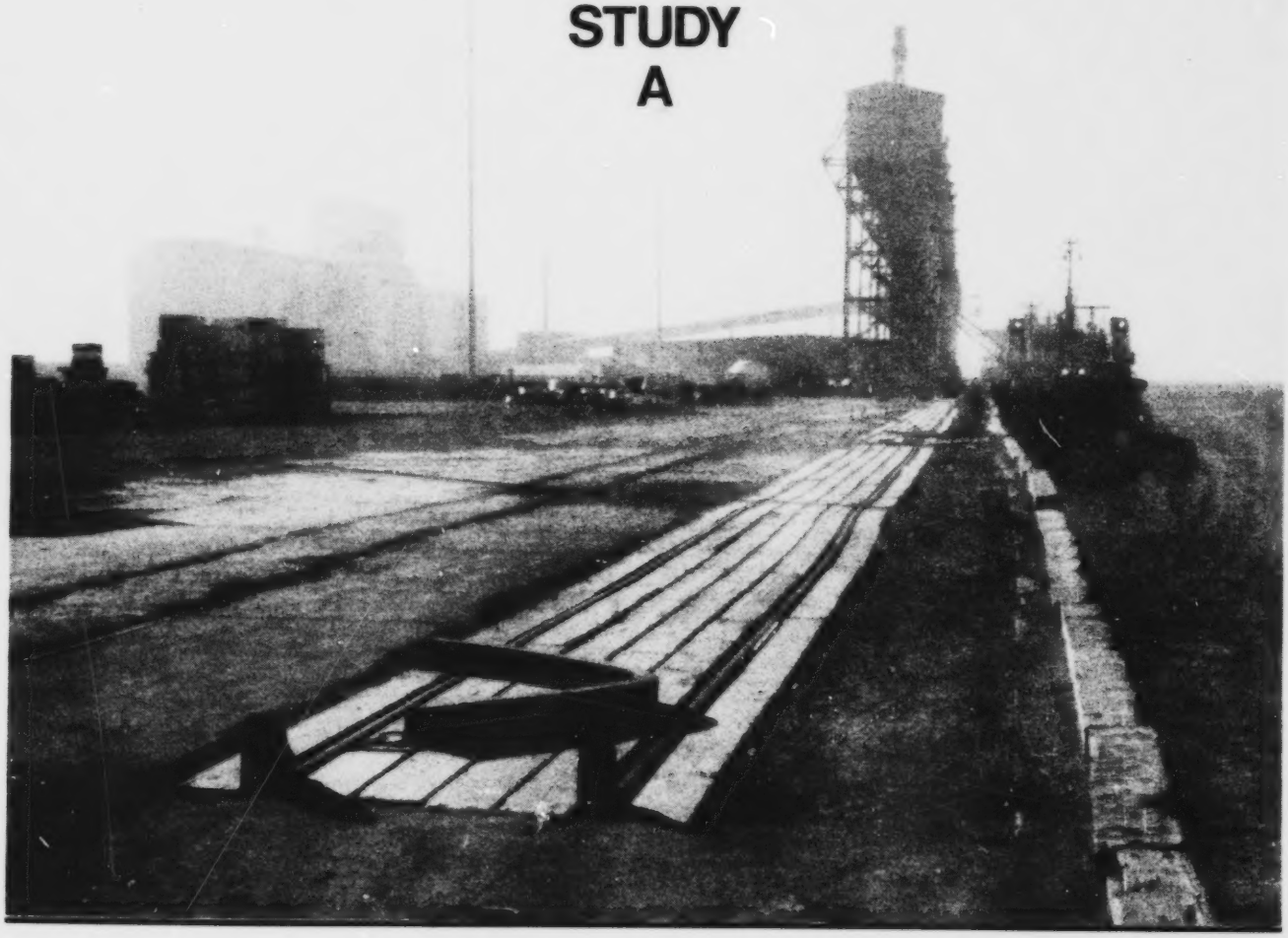
PORT OF CHURCHILL SEASON EXTENSION

STUDY A



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IBI GROUP

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PORT OF CHURCHILL
SEASON EXTENSION STUDY
STUDY A

Prepared for

GOVERNMENT OF CANADA
TRANSPORT CANADA

GOVERNMENT OF MANITOBA
HIGHWAYS AND TRANSPORTATION

By

IBI GROUP

in association with

Stevenson Hluchan Associates Limited

Canadian Offshore Data Analysis

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Gentlemen:

PORT OF CHURCHILL SEASON EXTENSION
STUDY A

We respectfully submit the above report presenting our findings on the technical feasibility, costs and benefits of extending the shipping season at the Port of Churchill. In accordance with the contract for this work, dated July 25, 1985, this report addresses one of the four studies comprising the overall Churchill study, as follows:

A. Season Extension;

B. Additional Commodities;

C. Resupply Operations;

D. Grain Shipping Costs.

The above four studies were all carried out by IBI Group and its associated sub-consultants, on an integrated basis; the accompanying report addresses the results of Study A only. The overall findings and results of Study A are summarized in an Executive Summary at the beginning of the report. The Summary follows the same structure as the main body of the report which, of course, presents the study findings and results in substantially greater detail.

We wish to acknowledge with thanks the advice and direction of the Steering Committee for this study under your co-chairmanship and the cooperation of the many people who provided information and opinions related to the study. The consultant team bears responsibility for our findings, conclusions and recommendations, as presented herein.

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IBI is a group of companies practising professional consulting and is affiliated with BIA Beinhaker/Irwin Associates Architects, Engineers, Planners

We hope that the economic comparisons presented in this report will assist the Government of Canada, the Government of Manitoba and other interested parties in reaching the most appropriate policy position regarding the Port of Churchill, in the long term interests of the country.

Yours sincerely,

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The contents of this report reflect the opinions of the Consultant and are not to be construed as the official policy of Transport Canada or Manitoba Highways and Transportation.

Dimensions and measurements contained in this report may appear in both imperial and metric units as a reflection of common usage and standard practice of the transportation industry.

ACKNOWLEDGMENT OF PARTICIPATION

The Study (Port Churchill Season Extension) was conducted on behalf of the Government of Canada, Transport Canada, and the Manitoba Department of Highways and Transportation, under the Canada-Manitoba Subsidiary Agreement on Churchill.

Consultant support to the IBI Group, the main consultants, was provided by the following firms:

Stevenson Hluchan & Associates - Consulting Engineers (Marine and Harbour Facilities)

Canadian Offshore Data Analysis (Atmospheric and Icing Conditions)

Captain E. Pelletier (retired) - (Coast Guard and ice breaker Operations)

J. Steve Merrett Consulting Services (Economic Analysis)

A multi-disciplinary steering committee composed of representatives from Transport Canada and the Manitoba Department of Highways and Transportation provided overall direction and facilitated information exchange with relevant organizations and individuals. The governments of the Province of Alberta and the Province of Saskatchewan also provided senior support to the steering committee and the Study.

The contribution of all participants is gratefully acknowledged. Responsibility for the findings and conclusions presented herein rests with the consultants.

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PORT OF CHURCHILL SEASON EXTENSION

STUDY A

EXECUTIVE SUMMARY

1. STUDY OBJECTIVES AND SCOPE

This study was conducted on behalf of the Government of Canada, Transport Canada, and the Government of Manitoba, Department of Highways and Transportation, under the Canada-Manitoba Subsidiary Agreement on Churchill. It is part of an overall study of the Port of Churchill conducted on an integrated basis by IBI Group and its associated consultants, with the following components:

- Study A: Season Extension;
- Study B: Additional Commodities;
- Study C: Resupply Operations;
- Study D: Grain Shipping Costs.

This Executive Summary provides a brief overview of the objective, scope, major findings and conclusions of Study A.

Objective

As stated in the Terms of Reference, the study objective is as follows:

> to "evaluate the support requirements, the technical feasibility, the costs and the benefits of implementing an extension to the normal shipping season at the Port of Churchill."

Study Scope

The study is to assess the support requirement, technical feasibility and costs of providing marine services both en route and within the Port, including Port facilities as well as services. It is to identify the supply of vessels capable of operating during a season extension, assess the risks to vessels and the associated costs and estimate the freight rates that would apply. It is also to assess the incremental risk to the environment and any associated costs from season extension, and any technical problems and the associated costs of providing rail service to Churchill in an extended season.

The study is also to identify and evaluate the economic costs and benefits associated with season extension, in the context of estimated future traffic that would utilize the extended season, and to estimate the net benefits of season extension under various levels of future traffic. The sensitivity of net benefit estimates to variations in season extension length (both in the spring and the fall) is also to be assessed. Conclusions are to be drawn from the analysis and, if applicable, an action plan recommended proposing a sequence of necessary events and investments that would be required to achieve a feasible season extension.

The following sections of this Executive Summary mirror the structure of the report.

Major Issues

There are a number of major issues addressed in Chapter 1 of the report which provide a context for the remainder of the study, including insurance and regulatory constraints on season extension, and grain forecasts and availability. These are highlighted briefly in the following paragraphs.

Insurance and Regulatory Constraints

As noted in sub-section 1.3.1 of the report, insurance requirements of the London underwriters have, until late 1985, effectively limited the Churchill shipping season to about 12 weeks (July 26 through to October 18) or (with a surcharge on premiums of 25%) to October 25. Discussions between the Government of Manitoba, the Government of Canada and the insurance industry, held during the fall of 1985, resulted in an agreement by the London underwriters to review the insuring conditions for vessels trading into Churchill and, as an interim measure, to provide insurance and assess premiums on a case-by-case basis taking into account factors such as the time of season, type of vessel, captain's experience in ice navigation, and other relevant factors. A more comprehensive insurance agreement will be developed during 1986 under which the insurance season will fall within the regulations set by Canada's Arctic Waters Pollution Prevention Act (AWPPA), as is already the case for Canadian insurers. The new arrangements are expected to remove insurance availability and cost as a major impediment to use of the Port of Churchill for vessels operating within AWPPA regulations.

The AWPPA regulations divide the Canadian Arctic into control zones for navigation control and pollution control purposes. The earliest permissible arrival dates and latest departure dates for each zone are specified for each vessel classification, ranging from the highest class of ice strengthened vessel relevant to this study (Class A) to the lowest (Class D) and non-ice strengthened (Class E). The regulations are such that the approximate maximum allowable season at Churchill for type E vessels is about 100 days, for type D vessels about 118 days, for type C vessels about 140 days, for type B vessels about 145 days, and for type A vessels about 155 days. Under these regulations, a Class E vessel could enter Churchill on about July 24 at the earliest and would have to leave it by about October 29 at the latest. The relevant dates for a type D vessel are July 12 and November 6, while those for a type C vessel are

July 5 and November 21. To put this in context, of the 115 vessels which used the Port of Churchill during the years 1977-1984 inclusive for which classification data is available (there were 163 vessels in total of which 48 were not classified) 41 vessels or 36% were not ice strengthened and 74 vessels or 64% were ice strengthened Type D or better). This suggests that, operating within AWPPA limits, over one third of the types of vessels historically using the Port could operate within a 100 day season and the remainder of almost two thirds could operate in an extended season of 118 days or more, depending on their degree of ice strengthening.

Grain Forecasts and Availability

A number of forecasts of Canadian grain production and export levels were reviewed in the context of recent trends and it was concluded that the projections to the year 1990 prepared in 1984 by the Canada Grains Council are still valid; these were therefore adopted as the base case projection for the study. This projection shows total grain exports through Churchill in 1990 of 888,000 tonnes, which is rounded to 900,000 tonnes or 75,000 tonnes per week over the normal 12 week season between July 26 and October 18. The base case economic evaluation of season extension (outlined below in Section 7 and in more detail in Chapter 7 of the report) is therefore based on a throughput of 75,000 tonnes per week; to test the sensitivity of season extension to higher or lower levels of Port usage, throughput levels of 65,000 tonnes per week and 85,000 tonnes per week are also analyzed.

Drawing upon the findings of Study D regarding the areas in Northern Saskatchewan and Manitoba for which the rail rate to Churchill is lower than that to any other grain port (the Churchill rail rate advantage area) an analysis is made of the availability of grain in that area in relation to potential Churchill throughput levels for an extended season.

To illustrate this, a hypothetical extended season of 20 weeks, at a Churchill throughput rate of 85,000 tonnes per week, giving a hypothetical seasonal throughput of 1,700,000 tonnes, was examined. As shown more fully in sub-section 1.3.2, even under this maximum throughput scenario, the Port of Churchill would be handling only 9.3% of the total Canadian export grain moving through Atlantic seaboard ports and Churchill's share of the projected increase in wheat and barley production in the Churchill rail rate advantage area (over the 1976-81 base period of the Canadian Grains Council study) would be about 33%, leaving about two thirds of the increased production to move through Thunder Bay.. These estimates are for 1990, based on the Canada Grains Council projection referred to earlier.

2. RAIL LINE AND ELEVATOR/PORT THROUGHPUT CAPABILITY

Chapter 2 provides an assessment of the throughput capability of the Churchill delivery system, including the rail line, rail/elevator interface, elevator, and elevator/vessel interface. This is based on current rated capacities of the various system components as discussed with operating staff of the railway, elevator and Port and, equally important, on demonstrated throughput during the year 1976 (when 719,100 tonnes were exported) and 1977 (when 755,200 tonnes were exported). These data show that the Churchill system is routinely capable of handling 70-75,000 tonnes per week and has demonstrated an ability to deliver higher volumes (80-85,000 tonnes per week) over two to three week periods. This analysis provides the basis for the higher throughput level (85,000 tonnes per week) selected for analysis in the economic evaluation of season extension.

The capability of the rail line and Port to deliver grain was then examined for a period of potential extension in the fall (from October 18 to as late as December 6) and in the spring, from July 26 to as

early as July 6). As pointed out in Section 2.4 of the report, it was concluded that the rail and elevator/Port capacity data which apply to operations in the normal 12 week season are also applicable for potential extensions of up to 7 weeks in the fall and up to 3 weeks in the spring. This assessment applies both to the existing system (using boxcars) and for the future system (for the period from the late 1980's onward) which could use rehabilitated boxcars, the new articulated hopper car which is being developed and tested currently on the Churchill line, or conventional hopper cars on a refurbished Churchill line. For purposes of the season extension economic evaluation, the articulated hopper car was used as the basis for analysis (drawing on the findings of Study D in this regard) but it is recognized that more data on the costs/capability of the articulated hopper car and on the costs/effectiveness of refurbishing the rail line will be required (from parallel studies which are to report during 1986 and 1987) before more definitive findings can be developed in this area. Regardless of which of the three options is selected for the future, it is concluded that the capability of the rail and elevator/Port delivery system for grain export movements will be as good during the extended season as during the normal season.

3. SEASON EXTENSION IN PORT

Chapter 3 of the study presents a description of Port facilities and operations, ice conditions in the Port, historical variations in weather and ice conditions, a week-by-week description of ice formation in the Port during the fall season based on experience over the past 20 years, and an assessment of possible ice management techniques to maintain late season operations in the harbour.

It is pointed out that the harbour is generally clear of ice about a month before the normal season opening at the end of July, such that the constraint on extending the season in the spring is en route ice conditions rather than conditions in the harbour.

The recent decision to construct a new tug for the harbour will remove an existing constraint at the end of the season, since the lesser draft of the new tug will allow it to enter the winter berth later than has been possible for the existing tug "Twolan". In order to achieve this, a building would have to be constructed to prevent moisture accumulation in the aggregate material used to seal off the winter berth from tidal action.

In terms of harbour ice conditions in the fall, a significant improvement has resulted from diversion of the Churchill River by Manitoba Hydro in 1980 for electrical power generation on the Nelson River. Prior to this diversion, which reduced typical October flow rates in the lower part of the river from about 820 cubic metres per second to about 130 cubic metres per second, the river used to dump significant concentrations of ice cakes and slush into the harbour which caused great difficulty to late season shipping. Since the diversion, with the reduced flow, most ice which forms from upstream snow storms becomes trapped at the rapids just south of the harbour and there is less formation of ice particles at the rapids, such that harbour ice problems have been substantially reduced.

Assessment of alternative ice management techniques led to the conclusion that ice suppression techniques (e.g. thermal discharge, bubblers) would be of minimal use because of the river current and tidal action, ice removal techniques would be very expensive, ice diversion (e.g. with a boom or barrage upstream of the wharf) is probably not warranted since the river diversion, and the most appropriate technique is ice breaking using the new harbour tug for ice thicknesses of up to 30 cm of slush ice and Canadian Coast Guard icebreakers, if necessary, for greater thicknesses. This would allow operation of the harbour to

November 15 in most years, with the need for conventional icebreaker support only on a restricted and occasional basis in years of heavier ice (estimated at about one year in seven). For such restricted harbour icebreaker operations by the Coast Guard vessels it would not be necessary to dredge the turning basin in the harbour; for season expansion beyond November 15, however, such dredging would be required to allow more extensive icebreaker operations in the harbour under heavier ice conditions, and these costs were included in the economic evaluation.

In summary, physical constraints on fall season extension in the harbour can be removed with relatively minor investments for the period to mid-November and, with an additional investment of about $3.1 million for harbour dredging, for the period until December 6. While the AWPPA regulations require non-ice strengthened vessels to leave Churchill by about October 29 and Type D vessels to leave by about November 6, these constraints could possibly be relieved with icebreaker escort and a change of the regulations,or the AWPPA regulations could be observed, allowing only the appropriately ice-strengthened vessels to use the Port up to the final closing date. These factors, and the costs of relieving the constraints and allowing Port operations into successively later weeks during the fall, are taken into account in the economic evaluation of season extension.

4. SEASON EXTENSION EN ROUTE

Chapter 4 of the report provides a quantitative assessment of ice conditions affecting marine navigation between the Port of Churchill and Cape Chidley at the eastern end of Hudson Strait. Based on ice data for the past 25 years, tabulations are provided (in greater detail in Appendix A) showing the number of nautical miles along the route for which various types of ice conditions are likely to be experienced in each specific week of an extended season, for years of good ice conditions, moderate (average) ice conditions and heavy ice conditions, respectively.

The estimated vessel delays for a season extension at the beginning of the normal shipping season are summarized in Exhibit 4.4 of the report. It shows that there are no extreme delays likely to be experienced in the week July 20-26, with most values being six hours or less. During the week of July 13-19 delays of less than 1-1/2 days are likely except for about one year in 12. For the week of July 6-12 the exhibit shows that, even with icebreaker escort over sections with significant ice coverage, minimum delays of 1 to 5 days would be likely (added to a base sailing time of 3.7 days) and additional delays of 1 to 3 days may be caused if ice pressure conditions develop.

Estimated en route vessel delays due to ice conditions during an extended fall season are presented in Exhibit 4.6 of the report. It shows that delays do not become noticeable until the week of November 16-22, in which delays are likely to be greater than 1 day long in slightly more than 1 out of every 4 years and up to 3 days long in 1 out of 11 years. The ice conditions during the week of November 23-29 lead to an expected delay of up to 5 days in 1 out of 10 years and a delay of over 1 day in 1 out of 2 years. For the first week in December expected delays would be in excess of 3 days about every second year and in excess of 5 days about 1 year in 6. These estimates include icebreaker support as appropriate; a delay of 5 days represents an increase of about 20% in the total voyage time (including 5 days in Port), increasing it from about 27 to about 32 days. Other climatic conditions affecting marine navigation to Churchill are also discussed in Chapter 4, including temperatures, wind directions and velocities and daylight hours.

The availability of ice strengthened vessels is also assessed (Section 4.4), and it is noted that the USSR has approximately 1,000 such vessels, with an additional 50-90 owned by other Eastern European countries. There are approximately 45 ice strengthened vessels suitable for the grain trade registered in Scandanavian countries. Fednav is the only Canadian shipping company that owns and operates ice strengthened vessels under Canadian registry. This company has 10 vessels which fall into the AWPPA type B category. These have dead weight tonnages (DWT) of

28,000 to 30,000. As pointed out above in Section 1, about two thirds of the vessels using the Port of Churchill during the years 1977-1984, for which registry information is available, were ice strengthened Type D or better.

Icebreaker escort requirements under various ice conditions for each of the season extension weeks studied were estimated and are summarized in Exhibit 4.12 of the report. It shows that in years of moderate (average) ice conditions during the week July 20-26 a Type E vessel would likely require up to about 100 nautical miles of icebreaker escort, while Type D and Type C vessels would likely require up to about 50 nautical miles of icebreaker escort. No escort is required in average ice years for any of the three vessel types up to November 8, although a Type E vessel would probably require 100-300 miles of escort during the week ending on that date in a year of heavy ice and Type D and C vessels would require 50-100 nautical miles of escort under those conditions. During the week November 9-15 a Type E vessel would require up to 100 nautical miles of escort in an average ice year while no escort would be required under those conditions for Type D or Type C vessels. Under heavy ice conditions in the week of November 9-15 use of a Type E vessel would be not advisable and icebreaker escort of about 100-250 nautical miles would likely be required for Type D and Type C vessels. Incremental costs of the required icebreaker escort are derived from these estimates and used in the economic evaluation presented in Chapter 7 of the report. This approach acknowledges that Canadian Coast Guard icebreakers are available in the area, in support of broader national and economic objectives; the approach allocates part of their operating cost during an extended season to the Churchill grain movement, based on the probability of this being required to assist grain vessels under various conditions and the likely miles of escort required.

Other support services required for season extension are discussed in section 4.6, including ice and weather advisory services, navigational aids, search and rescue, and insurance. There are improvements which can be made in the former three categories, relative to

season extension at Churchill, as suggested in that section and at the end of the report. As noted earlier, the impacts of insurance dates are in the process of being relaxed, such that the AWPPA season limits are expected to apply for insurance purposes in the future.

Environmental considerations of season extension are also discussed (section 4.7) and it is pointed out that environmental risks and associated costs which might result from season extension are expected to be negligible provided that the AWPPA season limits by vessel type, are not exceeded. While not recommended by this study, if the AWPPA limits were to be exceeded (e.g. by allowing operations outside of the limits, through a change of the legislation, under carefully specified conditions of icebreaker support, provision of information, and use of ice pilots) it would be desirable to conduct an environmental assessment before such changes were introduced in the future.

5. PORT SERVICES

Port services for season extension are discussed in Chapter 5, including tug assistance, ship repair, communications and pilotage/Port Warden services. The conclusions are carried forward for use in the economic evaluation of Chapter 7.

It is noted that the new tug which is to go into operation for the 1986 season will remove an earlier restriction on the shipping season in the fall (normally occurring about October 18) caused by winter berthing requirements of the existing tug "Twolan", such that the new tug should be available until at least November 15 to assist vessels entering and leaving the harbour and to provide ice breaking services within the harbour (for ice thicknesses up to about 30 cm)*. Icebreaker assistance

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* The tug is designed to operate in fast ice up to 15 cm thick. As discussed in sub-sections 3.2.7 and 3.5.2, this should be sufficient capability to keep the harbour open in most years until November 15, and occasional icebreaker support would be called on as required in years with heavy, early ice formation.

would be required for later season extensions as discussed in Chapter 4 of the report.

Ship repair services are found to be reasonably adequate for minor repairs of ice damage to vessels and it is suggested that any upgrading be left to the discretion of the local Ports Canada staff.

Season extension at Churchill will require a corresponding extension in the period of operation of the radio stations at Churchill and Frobisher Bay operated by the Canadian Coast Guard, at small incremental cost.

6. PORT RECONFIGURATION

An engineering and broad economic assessment was made of physical modifications that might be required in order to achieve the range of incremental season extensions under study and to assess whether the season extension objectives might be more cost-effectively achieved by relocating the Port facilities.

The main findings in terms of physical modifications are that no new facilities are required to achieve the proposed levels of season extension (one week in the spring and four weeks in the fall), on the assumption that the new tug will be able to move vessels in the harbour under ice thickness of up to 30 cm (generally to mid-November). The only physical facility identified as being required is a storage shed for holding the berm material necessary for constructing the winter berth seal at the end of the season; this would cost an estimated $30,000-$50,000. If a season extension beyond November 15 were contemplated, it would be necessary to dredge the existing turning basin to a depth of 9.2 m and to a width of 365 m (at a cost of $3.1 million) in order to allow operations by conventional icebreaker vessels within the harbour.

Two harbour relocation options were studied, both of which would aim to reduce the problems of floating ice and solid ice formation in the harbour during the fall. (As noted earlier these problems have been significantly decreased following diversion of the Churchill River by Manitoba Hydro in 1980.)

Option 1 would move the wharf and related Port facilities approximately 1 to 2 kilometres south of its present location. This would move the wharf out of the main ice flows as they currently exist, although the required dredging for the access channel might shift the main flow of the river and cause the original ice problems to recur. This option (illustrated in Exhibit 6.1 of the report) would have an estimated capital cost of about $85 million.

Option 2 would relocate the wharf and grain loading facilities outside of the rivermouth, in Hudson Bay. The proposed location would be directly east of Cape Merry, which would allow continued use of the existing grain elevator by providing a connecting conveyor. A substantial breakwater would be required, however, to provide both protection and accommodation for up to four grain vessels. Owing to the location in salt water and removed from the river currents, this option would be expected to experience a somewhat later freeze-over date on average than the existing facility. The estimated capital cost of this option would be about $78 million not including the cost of the grain conveyor.

It is concluded that neither option is economically attractive for season extension because the associated interest and annualized capital costs alone would exceed the gross operating revenues of the existing facilities at break-even throughput levels (about 700,000 tonnes per year). Since the analysis shows that, in general, en route conditions rather than harbour icing will be the constraining factor for season extension, it would be very difficult to justify Port relocation as a means to achieve season extension, particularly as long as the existing facility has adequate capacity and can remain in operation. A much greater net return would result from proceeding with season extension using the existing Port and elevator rather than building new facilities.

7. ECONOMIC EVALUATION OF SEASON EXTENSION

Chapter 7 presents an economic evaluation of the costs, benefits and net benefits of extending the Churchill shipping season in weekly increments, for up to three weeks at the beginning of the current season and up to seven weeks at the end of the season. For each individual week of an extended season, the costs of extending Port operations for that week are compared with the benefits associated with that week of operation. The major cost components are the marine, Port and elevator/rail costs of grain movements via Churchill during an extended season. The costs include all additional expenditures required above those which would be spent if Churchill were in use during the current season but not during the extended season (e.g. the marginal costs of season extension). The benefits are also those relative to no grain shipments during an extended season; these marginal benefits include benefits relating directly to maintaining or increasing grain shipments via the Port of Churchill and benefits (or disbenefits) relating directly to the reduction in grain shipments via Thunder Bay. It is assumed for this evaluation that any increase in grain shipments via Churchill would result in a corresponding decrease in grain shipments via Thunder Bay, reflecting the historic trade-offs of flows through the two ports, as discussed more fully in Study D.

The net benefits of season extension in one week increments (e.g. benefits minus costs) are examined in an aggregate fashion from the following five perspectives:

- Canadian economy;
- Western Canadian grain producers;
- Churchill region;
- Community of Churchill;
- Port of Churchill.

The sensitivity of estimated net benefits of season extension, particularly with regard to the Canadian economy, is assessed with respect to changes in major assumptions underlying the assessment, in particular regarding Churchill grain throughput levels, marine freight rate levels (low, medium, high) and en route ice conditions between Churchill and Cape Chidley (good, moderate, heavy). Other assumptions regarding the origins and destinations of grain which moves through Churchill and regarding the selling price of grain FOB Churchill (and the extent to which this price captures the marine freight rate advantage of the Churchill route) are also implicit in this analysis, as discussed more fully in Study D (in the Executive Summary, Chapter 4 and Chapter 7) and on the following two pages (regarding the Churchill selling price).

The base case evaluation is for a grain throughput of 75,000 tonnes per week (corresponding to the projected 1990 grain export level through Churchill of about 888,000 tonnes in a 12 week season as estimated by the Canada Grains Council in 1982. A lower throughput of 65,000 tonnes per week and a higher throughput of 85,000 tonnes per week were also assessed and, subsequently a substantially lower throughput of 40,000 tonnes per week was also evaluated. This corresponds to about 500,000 tonnes throughput during the existing 12 week season and almost 700,000 tonnes during a 17 week season. It should be noted that the economics of grain shipment at various levels through Churchill during the normal 12 week season are not treated in this evaluation; this is the subject of an extensive analysis presented in Study D.

The overall results of the economic evaluation for the base case of 75,000 tonnes per week throughput are presented in Exhibit 7.12 of the report. These estimates show that it is economically beneficial from the perspective of the Canadian economy to extend the shipping season at the Port of Churchill to the period from July 20 through November 15, an extension of one week at the beginning of the season and four weeks at the end of the season, to a total of 17 weeks as compared to the existing 12 week season.

This finding is based on the premise that the difference in grain price FOB Churchill versus the grain price FOB Thunder Bay reflects the difference in marine freight rates from each of those ports to overseas destinations (with Rotterdam used as a typical port). Unfortunately, owing to commercial confidentiality observed by the Canadian Wheat Board, it was not possible to obtain data on actual FOB grain selling prices at the two ports in order to verify this assumption. Based upon discussions during the study with grain shippers, traders and carriers, it was concluded by the study team that in years of strong grain markets (e.g. a sellers' market) this assumption will tend to be borne out by actual selling prices at the two ports while, in years of weak grain markets (a buyers' market) some grain customers taking delivery at Churchill may be able to negotiate a price lower than that reflecting the marine freight rate spread between Churchill and Thunder Bay. The customer may be motivated in this regard by preference for taking delivery at other Canadian ports and/or the expectation that, in a weak grain market the Canadian Wheat Board may be prepared to accept a slightly lower price at Churchill in order to maintain throughput levels at the Port while still retaining part of its rate advantage.

As shown in Exhibit 7.12, however, the net benefits of season extension during the proposed extension period under the base case are generally in the range of about $4.00-$16.00 per tonne in years of good or average ice conditions and in the range of about $2.00-$16.00 per tonne in years of heavy ice conditions; it seems likely, therefore, that even in years of weak grain markets (a buyers' market) a portion of the net benefit would still accrue to the Canadian economy even if the total marine freight rate spread is not completely reflected in the Churchill selling price for Canadian grain. A sensitivity assessment in Study D indicates that a discount of $2.00 per tonne (equal to about half of the ocean freight rate differential for the Churchill-Rotterdam movement versus the movement from a Lower St. Lawrence port to Rotterdam in a year of low ocean freight rates) in the selling price of grain FOB Churchill would not materially change the conclusions of that study. The net

benefits noted earlier in this paragraph and in Exhibit 7-12 show that the conclusions of Study A would also be basically unchanged if a $2.00 discount were experienced.

The sensitivity test at a Churchill throughput of 40,000 tonnes per week indicates that the economic findings outlined above would still apply at this lower level of grain exports through Churchill.

8. CONCLUSIONS AND RECOMMENDATIONS

Based on the study findings as outlined above and reported more fully in the first seven chapters of the report, Chapter 8 summarizes the overall conclusions of the study and presents a recommended action plan to achieve the level of season extension found to be economically viable.

Conclusions

The conclusions of the study, which draw also on the grain shipping cost analyses during the normal season of Study D, may be summarized as follows:

1. In terms of grain exports, as concluded in Study D, the Port will be economically viable only for higher levels of grain throughput, beyond approximately 600,000 tonnes per year in the 1990's and assuming that line related costs for the Churchill rail line will be borne by the federal government rather than by grain shippers (recognizing the broader role of the Port and the rail line in terms of national objectives such as defence, sovereignty and development in the North). Maintaining the Port and the railway line and not using it at or above such throughput levels is the worst option in terms of the economics of handling and transporting export grain.

2. There are net economic benefits to the Canadian economy for Churchill grain throughput levels of that magnitude or greater and for years of good, average and heavy ice conditions and under all three ocean freight rate scenarios, if the shipping season at the Port of Churchill is extended by one week in the spring and four weeks in the fall, creating a 17 week shipping

season from July 20 to November 15, inclusive. The economic analysis on which this conclusion is based assumes that all or most of the price advantage of Canadian export grain FOB Churchill versus FOB Thunder Bay (based on the marine freight rate spread between the two ports for shipments to Rotterdam) will be achieved by the Canadian export grain marketing program. While it is not possible to obtain hard data on grain selling prices FOB the two ports (owing to commercial confidentiality requirements of the Canadian Wheat Board) the study team concludes based on discussions with grain shippers and others that the above premise, while somewhat less valid in years of weak grain markets (a buyers' market), is likely to be valid in years of average grain markets and even more likely to be valid in years of strong grain markets (a sellers' market) such as those experienced in the late 1970's and early 1980's.

3. There are natural "break points" at the limits of the proposed extended season: a very minimal capital expenditure would be required to achieve the July 20-November 15 extended season; a more substantial expenditure of about $3.1 million would be required to achieve season extension beyond November 15, however, in order to dredge the harbour turning area to facilitate icebreaker operations within the harbour; the operating costs of season extension before July 20 and after November 15 would also be substantially higher because of the requirements of icebreaker escort en route, particularly in years of heavy ice conditions which tend to be experienced about one year in five.

4. To provide greater assurance that harbour operations could be maintained until November 15 without the need for occasional icebreaker operations within the harbour, the new tug should ideally be designed for operations in up to 30 cm of new, fast ice instead of up to 15 cm of fast ice and 30 cm of slush ice as it is now designed. The estimated cost of achieving this would be about $2 million, however, and it is unlikely that there would be time to produce the further-strengthened tug in time for summer, 1986 operations. Analyses presented early in sub-section 3.2.7 of the report indicate that the new tug, as currently designed, should be able to maintain operations up to November 15 in most years (about six out of seven) by operating continually as required in heavy ice years to keep fast ice from forming around the wharf and in the exit channel from the harbour. In the occasional year when this might not be possible, limited conventional icebreaker support within the

harbour would be called upon to clear the restricted area required for one or two vessels to leave the harbour during the last week of the season. Dredging of the turning area would not be required for such occasional icebreaker operations.

5. This suggests a strategy, therefore, in which the season would be extended as proposed and experience gained under the new extended season, before considering whether or not to strengthen the new tug further or to make further season extensions (e.g. to July 13 or July 6 in the spring and/or to November 22, November 29 or December 6 in the fall). The operating and cost experience obtained in the 17 week season would provide a much firmer basis than is now available regarding the feasibility of making the additional capital investments and experiencing the additional operating costs required for the longer season extension.

6. Operating experience (particularly in the larger throughput years of 1976 and 1977) and analysis of present operating capability indicate that the rail line, rail/elevator interface, elevator, elevator/vessel interface, and marine operation components of the Churchill grain delivery system have the capability to handle the throughput volumes examined in this study, both in the normal and the proposed extended season, with modest increased capital and operating costs as described in Chapter 7 of the report. This conclusion applies both to the existing delivery system and an improved rail system for operation during the 1990's, under any of the three options for rail improvement (boxcar rehabilitation, use of articulated hopper cars, or refurbishment of the line to carry conventional hopper cars).

7. The new insurance dates agreed to by the London underwriters and already observed by Canadian insurers, correspond to the season limits for marine navigation in the Canadian Arctic under Canada's Arctic Waters Pollution Prevention Act (AWPPA). Under these regulations, type E (unstrengthened) vessels are able to use the Port of Churchill for approximately 98 days per season, between about July 24 and about October 29. Type D vessels (the lowest classification of ice strengthened vessels) are able to use the Port for a season of about 118 days (from about July 12 until about November 6) and type C vessels for about 140 days (between about July 5 and about November 21).

8. There are two ways to address this situation: (1) declare the season open from July 20 to November 15 but only for operation of the various vessel types within the AWPPA limits; or (2) seek to change the AWPPA legislation to allow operation by vessel types E and D up to the limits of the new extended 17 week season but only under stringent conditions of provision of vessel information, use of ice advisors, and icebreaker escort for vessels operating outside of the AWPPA limits.

9. Our conclusion is that the first option is preferable, at least as a first step (e.g. operation of each vessel type within the AWPPA limits up to the limits of the proposed 17 week extended season). This is a logical first step which avoids the problems of a legislative change and an environmental assessment, and which is consistent with dates within which insurance will be available for vessels insured both by London underwriters and Canadian insurers.

10. The above conclusions are based on the premise that the Port of Churchill can and will be operated at viable levels of grain throughput and that appropriate funding and other arrangements would be forthcoming within an appropriate policy framework as discussed more fully in Study D.

11. The above conclusions are also drawn in the context of the findings of Study B (e.g. that there are no promising opportunities in sight regarding shipments of additional commodities through Churchill in significant quantities) and Study C (e.g. that an expanded resupply role for Churchill, both for marine and air resupply of Arctic communities, is economically viable and could lead to a doubling of the annual marine resupply shipments through Churchill, from about 16,000-25,000 tonnes per year to about 30-45,000 tonnes per year). If additional commodities were to become economically viable for shipment through the Port in future years (e.g. owing to the establishment of an aluminum smelter in Northern Manitoba, development of a new Arctic mine or oil production, etc.) the additional traffic would be expected to strengthen the conclusions stated above regarding the economic viability of extending the shipping season. Similarly, an extended shipping season would contribute to the ease of operations for expanded Arctic resupply through the Port, and operational conflicts between resupply and grain traffic are not anticipated for the recommended expanded resupply operations.

In summary, there is a good economic case to be made for expanding the existing 12 week shipping season of the Port of Churchill to 17 weeks, with subsequent consideration of possible further expansions based on the experience with the new expanded season. Minimal capital investments would be required to achieve the 17 week season and it is proposed that relevant vessel types would operate within the new season in accordance with AWPPA season limits for Class E and Class D vessels which are somewhat shorter than the 17 week season.

Proposed Action Plan

As noted in Point 10 of the Conclusions section above, the conclusions and recommendations presented here will apply only if there is an appropriate policy framework under which the Port of Churchill continues as a grain export port, at throughput levels which are high enough to be economic. Therefore, the first group of actions required in terms of season extension at the Port of Churchill must include the relevant policy decisions by the Government of Canada and discussions with the Canadian Wheat Board to establish an understanding regarding throughput levels to be used as targets by the CWB. In order to provide the CWB with marketing flexibility, any such targets would remain confidential and should probably be set on a multi-year basis; the policy statement by the Government of Canada would, of course, be public. The proposed action plan outlined below is based on the premise that export grain will consistently move through the Port at annual levels of about 600,000-700,000 tonnes per year or more.

Owing to the minimal physical and institutional requirements to achieve the proposed 17 week extended season, the action plan is relatively simple, as follows:

1. Representatives of the Government of Canada and the Government of Manitoba should continue discussions with London underwriters and representatives of the Canadian insurance industry in order to secure agreement as quickly as possible on new insurance arrangements for vessels using the Port of Churchill within the AWPPA season limits by type of vessel.

2. Arrangements should be made between Ports Canada and the Canadian Coast Guard for extended operation of the radio stations at Churchill and Frobisher Bay in order to serve the entire 17 week extended season and for standby icebreaker escort service for vessels en route between Churchill and Cape Chidley, in years where required by ice conditions.

3. In addition, arrangements should be made between these two agencies and other parties as appropriate to achieve the following in support of the extended season:

   - o establishment of an on-going monitoring program to provide year-by-year data on ice conditions in the harbour at Churchill, including ice conditions before freeze-over, date of freeze-over, ice thicknesses to the end of the new extended season and beyond, ice build-up on the dock face, and related weather conditions (it should be noted that this program, which was initiated in fall 1985 as recommended by the study team, can be carried out relatively easily by Ports Canada staff and therefore has little or no incremental cost);

   - o all vessels using Churchill in the extended season be required to report their positions twice daily to the Coast Guard, cooperate fully with the Ice Information Officer, and make use of the ice advisory service (based on aerial and satellite reconnaissance, ice forecasts, recommended shipping tracks and other relevant information) operated by the Atmospheric Environment Service and the Canadian Coast Guard; this procedure should also be required during the regular season;

   - o information services provided in the Port of Churchill be improved by providing access to ice charts, telephone contact with the Ice Information Officer to obtain routing advice and ice forecasts, and a formal mechanism for scheduling icebreaker escorts if required during an extended season. This service should also support coastal resupply operations out of the Port of Churchill;

   - o the regulations regarding the provision of icebreaker escort services should be determined and published by Transport Canada as should the rules to be followed by ships under escort both en route and in the harbour at Churchill;

- o a process of monitoring and forecasting ice conditions be developed including two week forecasts of sufficient accuracy to enable icebreaker escort needs to be determined plus the appropriate scheduling of these services, and 4-6 week forecasts with sufficient accuracy to categorize the type of conditions to be expected as either good, moderate or heavy ice conditions;

- o suitability of the land based navigational ranges at the Port of Churchill for operations within the harbour during the extended fall season be monitored and assessed, such that the improved land based radar beacons discussed in the report be installed if required; and

- o arrangements for flying in skilled personnel and materials from established shipyards in Eastern Canada, as may be required from time to time to carry out vessel repairs that might be required in the Port of Churchill, be formalized.

Insurance underwriters should be made aware of these arrangements.

In addition to this, information links should be established between Ports Canada, the Canadian Coast Guard and the Canadian Wheat Board such that the Coast Guard and the Port are informed in advance of anticipated grain vessel arrivals off Cape Chidley and the Coast Guard is informed of the dates of anticipated vessel departures from the Port, in order that the Coast Guard can ensure that regular radio communications are maintained with vessels en route, that vessel captains are aware of support and advisory services, and that the Coast Guard is in a position to provide icebreaker escort if required.

Finally, as noted earlier, if the extended 17 week season is brought into effect, it is recommended that the operating and cost experience in the extended season be monitored by Ports Canada and other participants such that an assessment can be made subsequently regarding the possible cost-effectiveness of additional season extensions.

1. INTRODUCTION: STUDY OBJECTIVES, SCOPE AND MAJOR ISSUES

1.1 BACKGROUND

IBI Group and its associated sub-consultants were requested by Transport Canada, Marine Administration and by the Manitoba Department of Highways and Transportation on July 24th, 1985 (T.C. Contract No. M0177) to perform four separate studies to determine the practicality and economic feasibility of expanding the utilization of the Port of Churchill, Manitoba for both import and export marine cargoes.

The four studies are:

Study A - Port Churchill Season Extension
Study B - Port Churchill Additional Commodities
Study C - Resupply Operations at Churchill
Study D - Port Churchill - Grain Shipping Costs

Study A was conducted by a multi-disciplinary team drawn from the following specialist firms:

Stevenson Hluchan and Associates - Toronto

Consulting engineers, specializing in harbour facilities design.

Canadian Offshore Data Analysts - Toronto

Specializing in atmospheric environment and marine icing.

Captain E. Pelletier (Retired) - Quebec City

(Former manager of fleet operations Canadian Coast Guard, Laurentian Region.) Specialist advisor on icebreaker operations and Arctic navigation.

J. Steve Merrett Consulting Services - Winnipeg

Consulting economists.

The work included a comprehensive review of a large number of relevant papers, reports, studies and articles as well as conducting interviews with many operating agencies, port users and support groups having a direct interest or knowledge of the historic and current situations at the Port of Churchill.

Study A is closely linked with Study D - Grain Shipping Costs. In particular, Study D contains a detailed assessment of Rail and Marine Shipping Costs for grain and these were used in summary form in the economic analysis of the season extension alternatives evaluated in Study A.

The results of Studies B and C indicate that the economics of season extension is not significantly influenced either by the requirements of the coastal resupply operations to the Keewatin area or by possible imports and exports of additional commodities through Churchill, owing to the relatively small volumes of these existing and potential movements relative to grain shipments. Therefore, this study assumes that season extension, if any, at Churchill, will have to be justified primarily on the basis of grain exports, the principal export commodity currently being shipped from the Port. The findings of Study B (no economically viable additional commodities are identified) and Study C (greater resupply activity at Churchill is potentially viable, but the total volumes are small relative to the capacity of the Port) are consistent with this assumption. The reverse interactions, that is, the impact of a season extension at Churchill on the feasibility of attracting additional commodities through the Port or expanding its resupply or grain export operations, are addressed in the reports on Studies B, C and D, respectively, and in the Summary Report for the entire study. Future opportunities for the economic movement of additional commodities through

Churchill would likely be enhanced by an extended shipping season and the viability of the season extension would, in turn, probably be enhanced by such additional movements.

This introductory chapter of the Study A report provides an overview discussion of the study scope and the major issues addressed in assessing the feasibility of season extension. Chapter 2 deals with the rail line capability as it would affect season extension. Chapter 3 deals with the in-Port requirements of season extension, and Chapter 4 describes the en route ice conditions and requirements. Chapter 5 and Chapter 6 assess the requirements for Port services and Port reconfiguration considerations respectively. Chapter 7 provides an economic assessment of costs and benefits if the Churchill season were extended in one week increments and presents the conclusions of the economic analysis. Chapter 8 presents the overall conclusion of the study and a recommended action plan.

1.2 STUDY OBJECTIVES AND SCOPE

1.2.1 Study Objectives

The primary objective of the study is to evaluate the technical and economic feasibility of implementing an extension to the normal shipping season at the Port of Churchill. Technical sub-objectives are to develop and assess relevant information regarding weather and icing impacts, support requirements, port services, supply of vessels, rail service, freight rates, traffic levels, and environmental risks as they relate to the feasibility of season extension. Economic sub-objectives consist of estimating the costs and benefits of season extension, on an incremental week-by-week basis, presenting estimates of net benefits, and showing the sensitivity of results to the duration of the season extension. If applicable, based on study findings, an action plan is to be presented, proposing a sequence of events and investments that would be necessary to achieve a feasible season extension.

1.2.2 Major Issues Affecting Study Scope

Season extension implies the possibility of an extension at the beginning of the season as well as at the end of the season. Presently, the Port is open in the spring for at least one month before Hudson Strait becomes navigable to vessels not having icebreaker support. Therefore, an earlier commencement of deep sea shipping at Churchill is not contingent upon Port conditions, but rather on ice conditions en route.

The technical factors associated with Port closure in the late fall and early winter fall into two categories:

(1) Port related ice problems including those associated with maneuvering vessels in the wharf areas under slush or temporary icing conditions and winter berthing of the Ports Canada tug Twolan.

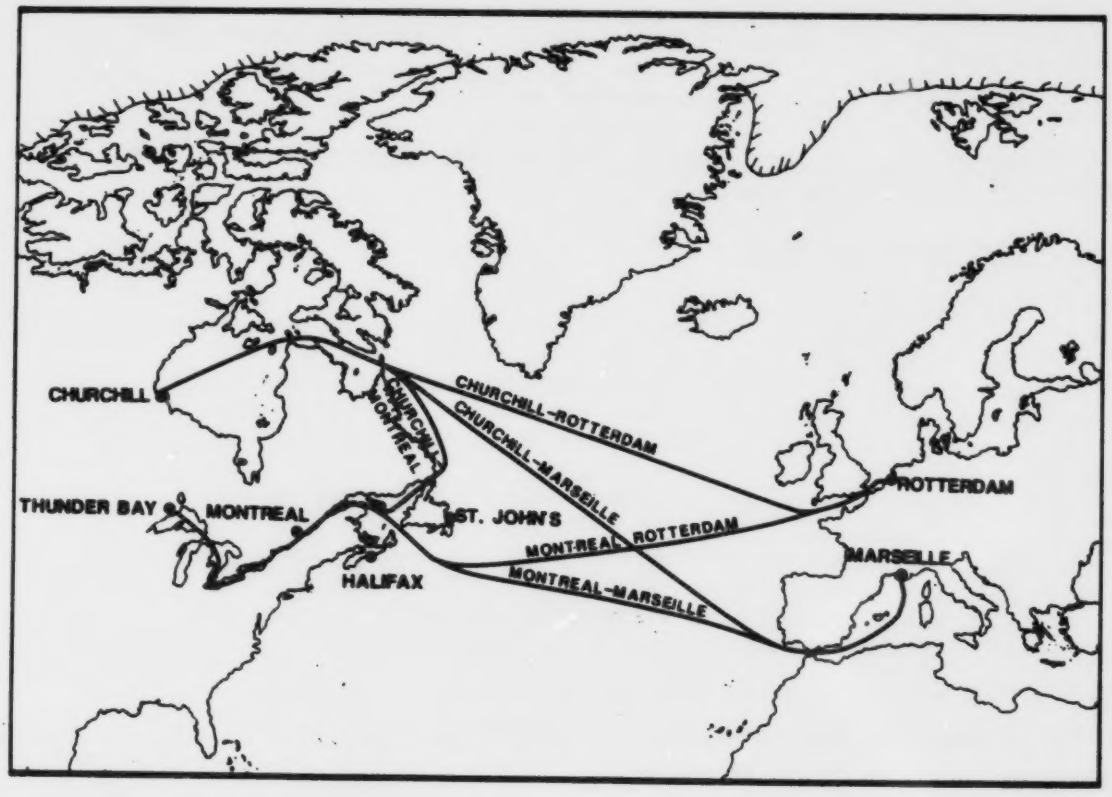
(2) Vessel maneuvering in Port and en route navigation as a result of the formation of first year ice.

Exhibit 1.1 illustrates typical marine routings from Churchill, Thunder Bay and Montreal, respectively, to Northwestern Europe (Rotterdam) and Southern Europe (Marseille).

The technical practicability and cost effectiveness assessment of season extension are based on season extension increments each of one week duration. The early opening period covers the three weeks preceding the normal opening date of July 26. The extension at the end of the season is examined in seven weekly increments beginning from the normal closing date of October 18 and extending to December 6. These normal dates are based on the season limits of July 23 and October 20 at Cape Chidley (as described more fully in sub-section 1.3.1 below), which were in effect at the commencement of the Study and historically had been fixed by the marine insurance underwriters. Due to recent developments (see sub-section 1.3.1), these limits no longer apply, but they have been retained as the starting point in the Study to provide historic continuity.

exhibit 1.1

PRINCIPAL MARINE ROUTINGS



CHURCHILL-ROTTERDAM - 3609 nm
CHURCHILL-MARSEILLE - 4740 nm
MONTREAL-ROTTERDAM - 3135 nm
MONTREAL-MARSEILLE - 3792 nm

THUNDER BAY-ROTTERDAM - 4196 nm
THUNDER BAY-MARSEILLE - 4853 nm

The Study includes assessment of the following primary factors:

1. Impact of Ice

   a) start of season ice assessment en route;
   b) end of season ice assessment in the harbour at Churchill;
   c) end of season ice assessment en route.

2. Capability of the elevator and the rail system serving the Port.

3. Port Reconfiguration

4. Evaluation

   This includes a week by week evaluation of the practicability and cost-effectiveness of season extension including the assessment of costs and benefits to:

   a) the Port of Churchill (including the grain elevators);
   b) the community of Churchill;
   c) the primary region served by Port Churchill;
   d) grain producers in Western Canada;
   e) Canada as a whole.

The costs and benefits are assessed on the basis of three indicative levels of grain throughput:

a) 65,000 tonnes per week (equivalent to 780,000 tonnes per year for a 12 week season), which represents approximately the rolling stock capacity (750,000 tonnes per year), which must be kept available by the railways for carrying grain to the Port of Churchill for each shipping season at least to 1990 under the Canada-Manitoba Subsidiary Agreement on Churchill.

b) 75,000 tonnes per week (900,000 tonnes per 12 week season), which is the approximate maximum historic weekly average throughput of the Port and corresponds approximately to the base case projection of 888,000 tonnes for 1990 through the Port of Churchill as discussed below in sub-section 1.3.3.

c) 85,000 tonnes per week (1,020,000 tonnes per 12 week season), which is approximately the practical present weekly capacity of the railway system and the elevator/Port facilities.

It should be noted that the Port has never had enough grain to sustain the levels shown under b) and c) above for the entire 12 week existing shipping season.

Other factors assessed in terms of season extension implications include:

a) Likely availability of grain for export;

b) Requirements for harbour services;

c) Navigation and information services;

d) Supply of vessels;

e) Freight rates; and

f) Environmental risks.

The sensitivity of the net benefit estimates to the duration of season extension and to other important factors such as the level of grain throughput, is also assessed.

1.3 OTHER MAJOR ISSUES

1.3.1 Insurance and AWPPA Constraints on Season Extension

There are two constraints, both of an institutional nature, which directly affect seasonal limits of navigation at Churchill for deep sea merchant shipping.

Historically, the dates of season opening and closure were determined largely by hull and cargo insurance considerations. Prior to the present season, the insurance coverage was available from London

underwriters at a special Churchill rate for vessels arriving at Cape Chidley, the eastern entrance to Hudson Strait on or after July 23 and departing the same point by October 20. The normal sailing time between Churchill and Cape Chidley is two or three days, so that the season at Churchill was limited to 85 days or about 12 weeks (26th of July through to the 18th of October). Supplementary insurance at a surcharge of 25 per cent covering an additional week (to October 25th) in the late fall was also available, but has seldom been used for grain shipment.

A second constraint on season length is the set of regulations under Canada's Arctic Waters Pollution Prevention Act (AWPPA). These regulations divide the Canadian Arctic into control zones for navigation control purposes. The earliest permissible arrival dates and latest departure dates for each zone are specified for each vessel classification, ranging from the highest class of ice strengthened vessel relevant to this study (Class A) to the lowest (Class D) and non-ice strengthened (Class E). The AWPPA control dates for Zone 14 (see Exhibit 1.2) which includes the Port of Churchill approaches and Zone 15 which includes Hudson Strait are as shown in the following table:

SEASON LIMITS UNDER AWPPA BY VESSEL TYPE

Vessel Type	Zone 14	Zone 15	Approximate Maximum Allowable Season at Churchill
Type A	June 25 to November 30 (159 days)	June 25 to December 5 (164 days)	June 29 to November 28 153 days
Type B	July 1 to November 30 (153 days)	July 1 to November 30 (153 days)	July 5 to November 26 145 days
Type C	July 1 to November 25 (148 days)	July 1 to November 25 (148 days)	July 5 to November 21 140 days
Type D	July 10 to November 10 (124 days)	July 5 to November 10 (129 days)	July 12 to November 6 118 days
Type E	July 20 to October 31 (104 days)	July 20 to November 5 (109 days)	July 24 to October 29 98 days

exhibit 1.2

AWPPA ZONES AND SEASONAL LIMITS AT CHURCHILL

VESSEL CATEGORY	ZONE 14 (NE-HUDSON BAY)	ZONE 15 (HUDSON STRAIT)	ZONE 16 (NW-HUDSON BAY)
Type A	June 25 - Nov. 30	June 25 - Dec. 5	June 20 - Nov. 20
Type B	July 1 - Nov. 30	July 1 - Nov. 30	June 20 - Nov. 10
Type C	July 1 - Nov. 25	July 1 - Nov. 25	June 25 - Nov. 10
Type D	July 10 - Nov. 10	July 5 - Nov. 10	July 1 - Oct. 31
Type E (Non-Ice Strengthened)	July 20 - Oct. 31	July 20 - Nov. 5	July 1 - Oct. 31

Source: Sailing Directions . Labrador and Hudson Bay . 5th Edition . 1983

Since the sailing time between Churchill and the eastern edge of Zone 14 is about two days and the sailing time is about four days between Churchill and the eastern edge of Zone 15, the season lengths at Churchill for the above vessel types in accordance with AWPPA regulations are about four days less than the numbers shown in parentheses above for Zone 14 or about eight days less than the numbers shown in parentheses for Zone 15. The last column in the Table above shows the maximum allowable season at Churchill allowing for the above sailing times and the most constraining entrance/exit dates from Zone 14 and Zone 15. The actual season length at Churchill could be slightly longer or shorter in a particular year if sailing times to the Zone limits are shorter or longer due to ice conditions.

Discussions during the summer of 1985 between representatives of the insurance industry and the transportation departments of the Government of Canada and the Government of Manitoba resulted in an agreement by the London underwriters to work within the AWPPA season limits, as has hitherto been done by Canadian underwriters. In future insurance coverage will be available for vessels meeting and operating within the AWPPA regulations. Within this context, London underwriters are undertaking a review of insuring conditions for vessels trading into Churchill. As an interim measure, the underwriters have undertaken to assess premiums on a case-by-case basis taking into account such factors as the time of season, type of vessel, experience of the ship's captain in ice navigation, owners, and other relevant factors.

As a consequence, future season limits will be set by AWPPA regulations, a de facto lengthening of the season by some 15 days (from about 85 to about 100 days for unstrengthened vessels) and this may encourage greater use of the Port. However, there could be some reduction in competition, since some older vessels operating in the spot market may be priced out because of reduced insurability.

The available evidence indicates that about two-thirds of the vessels serving Churchill are AWPPA Type D or better (Exhibit 3.4). As a consequence, the permissible operating season at Port Churchill for a substantial proportion of the vessels using the Port historically has been increased from 85 days to about 118 days. Further extension of the season could be achieved by using type C or higher ice class vessels. As noted above, the permissible season under AWPPA at Churchill for type C vessels would be about 140 days and the maximum permissible season (type A vessels) would be about 155 days or about 10 weeks longer than the historic 12 week season.

To put the above into context, the accident experience of vessels using Churchill has been reviewed and discussed with officials of the Port, the stevedoring company at the Port and other users. Since 1972, three major ice related accidents have occurred on the Churchill route which have required subsequent drydocking of the vessels to undergo major repairs. These accidents occurred in 1985 (Sealink), 1984 (Evangelina C) and 1972 (Silksworth). All three of the collisions with ice floes occurred in or near Hudson Strait at the beginning of the Churchill shipping season in late July or early August. Damages occurred in these accidents ranged from approximately $50,000 for the Sealink to about $1,000,000 for the Silksworth, and in each case, the vessel was also held up in drydock for a considerable time period. In addition to these major accidents, there have been a somewhat larger number - perhaps a dozen or so since 1972 - of minor ice related incidents on the Churchill route, each occasioning about $2,000 to $10,000 worth of repairs at the Port of Churchill and several days' delay to the vessel. In all such cases, the vessel was able to complete the grain movement successfully. Examples of these minor incidents include those involving the Hampton Lion in 1984, the Bandar Denta in 1983 and the Warkworth in 1972. Virtually all of these minor accidents also occurred near the beginning of the Churchill shipping season.

There is evidence that most accidents have been experienced by vessels whose captains and crews were inexperienced in navigating through waters where ice may be present. This suggests that most could have been avoided with experienced captains and crews and/or improved ice information and support services, as discussed below in Chapters 4 and 8.

1.3.2 Economic Implications of Port Usage Levels

At present the Port of Churchill has three major functions:

a) It serves for the export of grain, primarily wheat and barley (with some pellets and screenings in the years 1975-1981 inclusive), to Europe and Africa; a range of between 309,000 and 755,000 tonnes annually over the past 30 years, with an average annual throughput of 572,000 tonnes over that period.

b) It supports marine resupply operations of petroleum and dry cargoes by coastal carrier to six Arctic communities in the northwest part of Hudson Bay (approximately 24,000 tonnes annually).

c) It provides harbour and support facilities for general marine traffic operating in the vicinity.

Periodically, the Port has also handled bulk fuel imports (approximately 18,000 tonnes annually), imports of nickel concentrates from Rankin Inlet on Hudson Bay and (in one year) 50,000 tonnes of bulk sulphur exports. Resumption of oil imports to meet the needs of Churchill and for resupply of Arctic communities is a definite consideration as discussed in Study C.

In the 1950's and '60's, the Port also accommodated backhaul general cargoes primarily transported by the Dalgleish Shipping Lines. This type of cargo worldwide is increasingly transported in containers, but the potential volumes through Churchill for the foreseeable future are well below the minimum levels necessary to justify the required heavy capital investments in dockside ship to rail/storage container handling facilities.

Under normal circumstances, a major cost factor at ports and terminal elevators is the required level of staffing. The year round Port and elevator employment at Churchill has been approximately 20 to 25 persons. An additional 100 to 120 temporary employees are generally hired for the shipping season as required. The staffing requirements of the elevator are governed by single vessel loading rates which are more or less fixed by the capacity of the elevator. In busy years there are continuous queues of vessels anchored and waiting for loading such that the full complement of staff are fully utilized. In less busy years there are slack periods but, because two-thirds of the labour force is brought in from outside, minimum salaries are paid and guaranteed for the season in order to attract the quantity and quality of labour required.

Examination of labour and other cost factors of operating the Port and elevator as described in Chapter 7, shows that variable costs of operation at Churchill are about $3 per tonne and fixed costs are about $5 million per year. This means that fixed costs at Churchill would vary from about 80% in low volume years (such as 1985) to about 60% if the annual volume were about one million tonnes per year. (This latter percentage is similar to that for Thunder Bay.) The cost per tonne of moving grain through Churchill, whether in the normal season or an extended season, depends very much on the volume of movement, and the economics of season extension are also very dependent on volume levels.

The economic evaluation of season extension is therefore based on the initial assumption that increased use of the Port could occur in two stages: the first stage could be the increase in grain exports to near Port capacity levels during the historic 12 week season and the second step could be the extension of the operating season in stages with weekly grain flows in the extended season equalling the average weekly flows during the regular season. In practice, flow rates would fluctuate above and below average rates both within the existing and the extended season. Grain shipments from Canada are generally highest in the early summer months and lower in the late fall and winter months (see Exhibit C-6).

The sensitivity of season extension costs and benefits to different levels of grain throughput is therefore assessed, as described in Chapter 7, by estimating costs and benefits both during the normal season and the extended season, at the three levels of throughput (65,000, 75,000 and 85,000 tonnes per week respectively) which were described earlier in sub-section 1.2.2.

1.3.3 Grain Trends, Forecasts and Availability

Recent Trends

A major economic argument cited by some in opposition to extension of the shipping season at Churchill is the current low utilization of the Port for shipping grain during the existing season. Exports through Churchill in 1985 (359,000 tonnes) were less than half of the peak 755,000 tonnes shipped in 1977, as described more fully in Study D, and about one-third less than the average annual throughput for the years 1975-1984 inclusive which was about 542,000 tonnes.

Over the 10 year period from 1975 to 1984, worldwide grain exports from Canada increased from 14,125,000 tonnes to 24,070,000 tonnes or by 70.4 percent. Shipments through Eastern Canadian ports including Churchill over the same period increased from 8,497,000 tonnes to 13,911,000 tonnes or by 63.7 percent. Excluding Churchill, the shipments by way of Eastern ports increased by 68.6 percent. Shipments from Churchill over the same period declined 14 percent from 506,000 tonnes to 436,000 tonnes, with a further drop of 18 percent to 359,000 tonnes in 1985. Churchill's share of Prairie grain export shipments has dropped during this period from approximately three percent to slightly more than one percent.

In summary, grain shipments through all Eastern Canadian ports except Churchill, over the 10 year period under discussion increased by 5,484,000 tonnes while those through Churchill decreased by 70,000 tonnes.

Lower than average crop yields during the past two years and recent export market weaknesses may help explain the reduced exports through Churchill in 1984 and again in 1985, but at best it is clear that the role of Churchill as a grain exporting port has been static or declining during a decade of substantial growth in grain exports from Canada's Eastern ports. Crop yields in the Churchill rail rate advantage area were generally better than in other parts of the Prairies during 1984 and 1985, which indicates that increased proportions of grain from this area were cross hauled to more distant ports.

Factors Which May Influence Trends

A number of objective reasons have been cited by various authorities to explain Churchill's declining role. These include:

- the short normal shipping season (85 days);
- overlap of the Churchill shipping season with the grain harvesting season in the Northern Hemisphere;
- high marine insurance rates;
- physical limitations of the system.

These and other factors are examined by this Study and no worsening of any is identified which would help explain the decline in traffic. On the contrary, as shown in Study D, the relative economics of the Port has improved in that the recent decline in marine shipping rates has reduced the ocean shipping rate advantage of lower St. Lawrence ports relative to Churchill. (It has also decreased the marine shipping rate advantage of Churchill relative to direct shipment from Thunder Bay, but direct ocean shipments of grain (using salties) from Thunder Bay are small relative to movement through lower St. Lawrence ports and are declining as ocean vessel sizes increase.) The capacity of each physical element of the delivery system including the railway, the elevator and Port facilities, is also reviewed. Adequate capacity exists to export approximately

2.5 to 3 times the 1985 throughput. The Port can, with some restrictions on loading time, accommodate vessels up to Panamax size (about 45,000 DWT), but actual vessels loaded average approximately 60-75 percent of Panamax.

A number of institutional and policy factors perceived to be inhibiting the use of the Port have also been identified by a number of agencies and other interested parties in the past. These factors are of a subjective nature and their impacts on grain flows through the Port are difficult to confirm, to quantify or to predict. Reasons given by grain shippers, shipping companies and others for not using Churchill are presented here as background information:

- the high cost to the grain shipper of marketing grain for shipment through the Port;
- the apparent unwillingness of some buyers to purchase grain at Churchill;
- the difficulty by the grain shipper to find adequate grain of the right type and grade which can be marketed through Churchill when required during the late summer and early fall;
- the unwillingness of ship owners to accept charters, and concerns by some ship operators regarding shipping hazards in northern waters;
- concerns for the economic viability of the St. Lawrence System and the continued profitability of related private sector facilities;
- loss of grain markets (primarily countries now within the European Economic Community) traditionally served from Churchill;
- the impracticality of exporting non-Board[1] grains

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1. Board grains are wheat, oats and barley and are so designated because the CWB controls their export marketing and movement out of Canada. As noted above, the principal non-Board grains are rye, canola and flax seed, and there are a large number of additional non-Board grains with smaller movements, as listed in Schedule A of the Western Grain Transportation Act promulgated in 1983.

through Churchill. The principal non-Board grains produced in Western Canada are rye, canola (an improved variety of rape seed) and flax seed. These grains are commonly sold on the futures market and because overseas export volumes are small, a futures market for Churchill delivery of these grains does not exist;

- o lack of interest by grain companies in using Churchill because they do not have terminal elevators at Churchill and because of perceived operational complexities of exporting grain through the Port;
- o lack of perception by grain growers of the economic advantage of shipping through Churchill, since savings are not routinely identified;
- o absence of a clear policy statement by the Government of Canada regarding the future role and funding of the Port of Churchill.

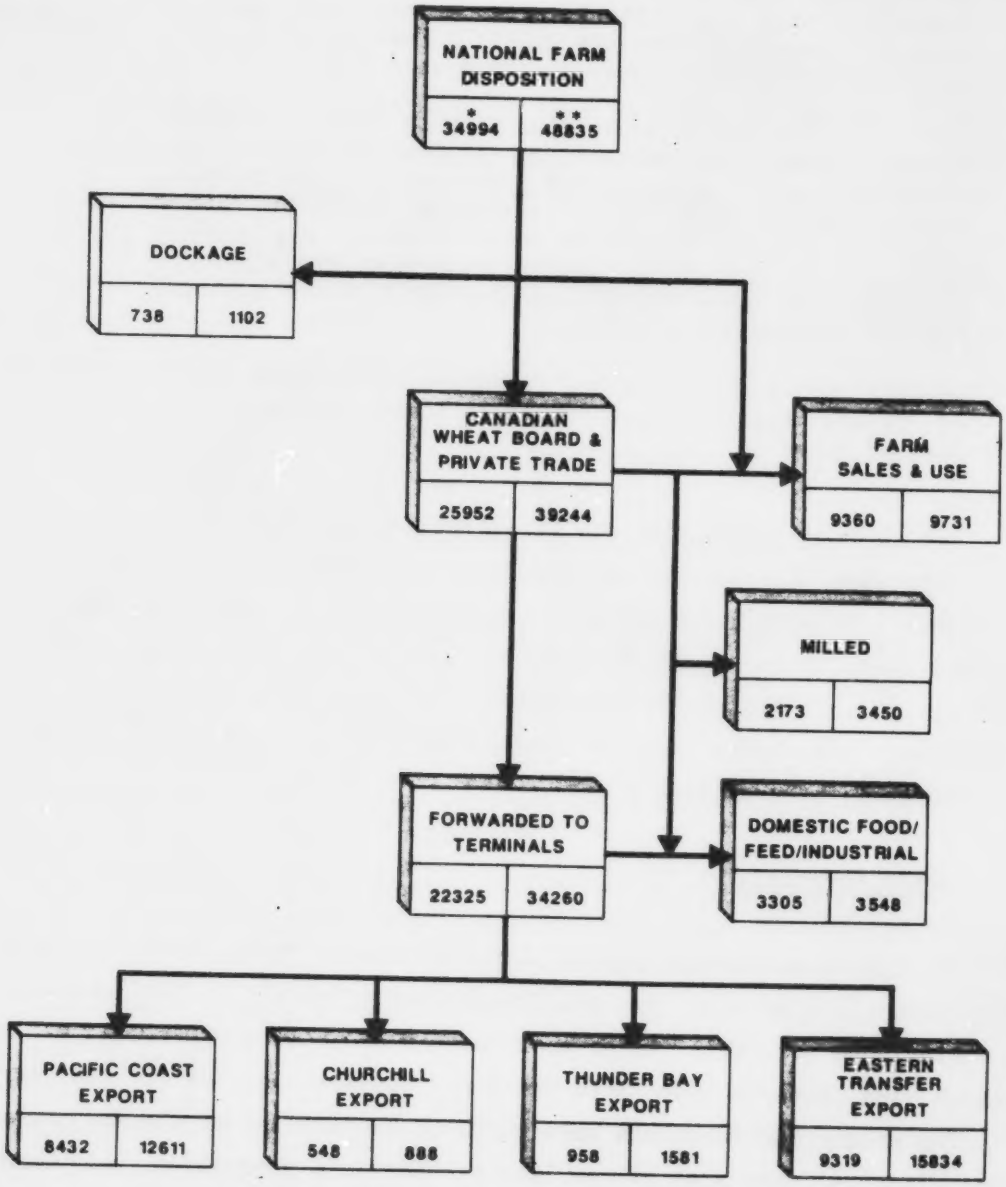
The primary responsibility for directing the flow of Board grains (wheat, oats and barley) through the Canadian port system rests with the CWB. Discussions with Board officials were hampered by commercial secrecy limitations (e.g. in terms of CWB selling prices of grain at various Canadian ports) such that it is not possible to state more definitively the marketing and other factors which define the size and mix of the Board's Churchill program each year.

Grain Forecasts

A comprehensive assessment of the prospects for the Prairie grain industry was carried out by the Canada Grains Council in 1982 (Exhibit 1.3). Included in this assessment was a projection of Prairie grain production and exports for both Board and non-Board grains for the year 1990. The production forecasts were based on projections of the following physical factors: the area of new land brought into production, decreases in the area of land allocated to summer fallow, and improved crop yields. The export forecasts were based on the patterns of Prairie grain flows experienced in 1976/77 to 1980/81, modified to reflect potential changes in demand for grain used within the Prairie region. The forecasts derived

exhibit 1.3

1976-81 HISTORIC & PROJECTED 1990 ANNUAL FLOWS OF MAJOR GRAINS - PRAIRIE PROVINCES



GRAINS : WHEAT, OATS, BARLEY, CANOLA (RAPESEED), FLAXSEED

*** 1976-81 base year flow** (thousands of tonnes) **** projected 1990 flow**

Source : Canada Grains Council, Prospects for the Prairie Grain Industry 1990, November 1982.

in this manner indicated combined wheat and barley exports in 1990 of 27,687,000 tonnes of which 15,894,000 tonnes were assigned to Eastern Canadian Ports and 880,000 tonnes (of wheat and barley) to Churchill. Shipments of oats, canola and flax seed through Eastern Canadian ports were projected at 1,521,000 tonnes - none of which were predicted to flow through Churchill.

If the Canada Grains Council projected flows of wheat and barley combined were to materialize in 1990, the incremental flows over the average 1976-81 base year for the four terminal systems would be as shown as Exhibit 1.3.

In 1982, members of the Faculty of Administrative Studies, York University, prepared grain forecasts for 1990 as part of a forecast of Canadian dry bulk vessel requirements for the Great Lakes. The forecast model developed for Prairie grains was based on two independent variables: total acreage planted in grain, and grain land productivity. The projection of grain production for 1990 is 46.3 million tonnes. This compares with 48.8 million tonnes forecast (44.2 million tonnes of wheat and barley) by the Canada Grains Council, also in 1982. The York University Study did not provide detailed forecasts by grain type or crop district as did the Canada Grains Council projection.

By referring to historic movement trends, the York forecasters projected 1990 flows of 16,600,000 tonnes of grain directly from Thunder Bay of which 12,900,000 tonnes would be by Eastern transfer. The corresponding projections by the Canada Grain Council were 17,415,000 tonnes and 15,834,000 tonnes respectively. The two projections are largely in agreement with respect to grain production. The different methodology used by the York University forecast of grain movements possibly understates the potential grain flows through Eastern Canada ports.

The Canada Grains Council projections are most useful in the context of the Churchill Study since they also provide information on projected grain production by each of five grain types and by standard crop district. Members of the study team discussed the continuing validity of its 1982 grain objectives with a member of the Canada Grains Council staff and were informed that the Council considers the 1990 projection to be still valid, notwithstanding the lower crops and sales of the past two years. The study team concurs with this view, noting that the grain industry is subject to substantial annual fluctuations and that the factors of Canadian production capability and growth in world demand for grain underlying the projection are basically unchanged.

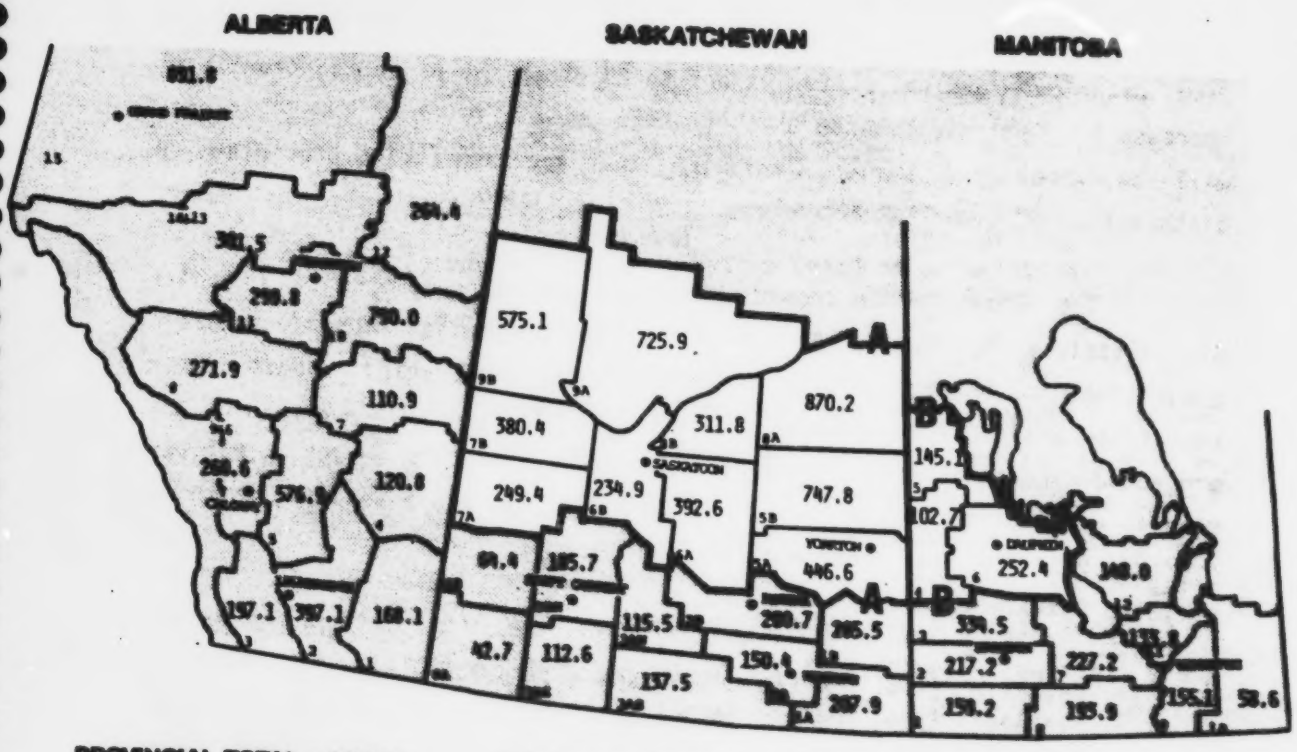
Accordingly, the Canada Grains Council projection of 1990 grain production and export volumes is adopted as the basic forecast for purposes of this study. As noted earlier and summarized in Exhibit 1.3, this suggests total grain exports through Churchill in 1990 of 888,000 tonnes, of which 855,000 would be wheat and barley. Actual volumes will, of course, be determined by CWB sales and grain movement policies, which is why several levels of throughput are used for the economic analysis.

Geographic Distribution of Incremental Grain Production

The Port of Churchill historically has received grain from practically all Prairie crop districts. However, as described in Study D, it offers the greatest transportation benefits to shipments from CN grain delivery points in crop districts located in Northern Manitoba and Saskatchewan. The availability of grain in these crop districts (shown in Exhibit 1.4) is of particular interest in the context of possible season extension at Churchill.

exhibit 1.4

TOTAL PROJECTED INCREASES* IN PRODUCTION TO 1990 BY CROP DISTRICT (000 tonnes)



PROVINCIAL TOTAL = 4650.9

PROVINCIAL TOTAL = 6477.8
ZONE A = 4934.7

PROVINCIAL TOTAL = 2127.7
ZONE B = 800.2

* over average 1976–1981 production levels

Source : Canada Grains Council, Prospects for the Prairie Grain Industry 1990, November 1982.

The projected increase in total grain output for the five major grains[2] for the year 1990 over the average for the base period 1977 to 1981 is approximately 2,127,700 tonnes for Manitoba, 6,477,600 tonnes for Saskatchewan and 4,650,900 tonnes for Alberta.

The crop districts in Manitoba closest to Churchill (districts 4, 5 and 6) have a projected increase in production of 500,200 tonnes of the five principal grains. (Equivalent to 23.5% of the projected provincial increase.) It is estimated that, of this amount, 87.6% or 438,000 tonnes will be wheat and barley, assuming that the base period province-wide distribution of grain types applies.

The Saskatchewan crop districts of special relevance to Churchill are districts 5, 6, 7, 8 and 9. The projected increase in grain production in these districts to 1990 over the base period production for the five grain types combined is 4,934,700 tonnes or 76.2% of the projected increase for the entire province. Of this amount, 4,636,000 tonnes are estimated to be wheat and barley, again assuming that the average base period distributions for the province apply directly to Northern Saskatchewan.

Potential Effect of Churchill Season Extension on Grain Availability at Eastern Canadian Ports

Over the 1976-81 base period of the Canada Grains Council Study, an average 548,000 tonnes of grain annually or 1.6% of total grain production flowed through Churchill. In terms of exports, this represented 2.8% of Canadian worldwide exports and 5.1% of exports through Eastern Canadian Ports and Churchill combined.

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2. Wheat, oats, barley, canola and flax seed as projected in 1982 by the Canada Grains Council.

Three possible rates of flow through Churchill are considered for the economic analysis. These are:

1) 750,000 tonnes (62,500 tonnes/week over the normal 12 week season) specified in the Canada/Manitoba Subsidiary Agreement; shown to be achievable in 1976 and 1977, and represents the rolling stock capacity which must be maintained at least to 1990 under the Canada-Manitoba Subsidiary Agreement on Churchill;

2) 888,000 tonnes (74,000 tonnes/week over 12 weeks) projected for 1990 by the Canada Grains Council and which is the approximate historic maximum weekly average throughput experienced at the Port;

3) 996,000 tonnes (about 83,000 tonnes/week over 12 weeks) the adjusted demonstrated weekly capacity of the railway, elevator and Port system based on actual 1976 grain deliveries, as shown below in Chapter 2 and in Chapter 6 of Study D.

For ease of presentation, these figures are rounded to 65,000 tonnes, 75,000 tonnes and 85,000 tonnes weekly respectively. It will be noted that the middle figure of the three corresponds to the Canada Grains Council 1990 projection of grain flow through Churchill, which we have adopted as the base forecast, while the other two figures represent achievable higher and lower throughput levels. A single forecast or scenario is not appropriate because grain flows through Churchill are a matter of CWB policy and sales programming.

These throughputs were selected for the purpose of determining the cost effectiveness of season extension; they are not intended to reflect the ultimate capacity of the Port, but rather are believed to represent demonstrated practical throughputs which can be achieved without significant new investment in rail, elevator or Port facilities or major changes in Port operating procedures except the introduction of double shifts.

The maximum season extension under consideration is an advanced opening by up to two weeks and delayed closure by as much as seven weeks

over the present shipping season as determined until recently by insurance availability. This might increase the shipping season at Churchill from the present 12 weeks to a maximum of about 21 weeks. While the most cost-effective level of season extension is described elsewhere in this report, a 20 week season is hypothesized here as a maximum new season solely for the purpose of assessing the future availability of grain for Churchill and other Eastern Canadian ports under this assumption.

The maximum Port throughput under the three cases would be as follows in a twenty week season:

Case	Throughput Rate (tonnes/week)	Hypothetical Seasonal Throughput Over 20 Weeks (tonnes)	Approximate Increase Over 1990 Projection * (tonnes)
1	65,000	1,300,000	400,000
2	75,000	1,500,000	600,000
3	85,000	1,700,000	800,000

* The 1990 projection referred to is the Canada Grains Council projection of 888,000 tonnes (rounded to 900,000 tonnes) annual throughput for Churchill.

The projected incremental increase in flows through the other Eastern Canadian ports by 1990 over the base period was 7,138,000 tonnes. Cases 1, 2 and 3, represent reductions in potential incremental growth in other Eastern Canadian port export flows of 5.6%, 8.4% and 11.2% respectively.

Flows through Churchill as a per cent of combined Atlantic flows would be as follows:

Churchill Grain Flows (Maximum Season)
as Percentage of 1990
Projected Flows Through
Eastern Seaboard Canadian Ports

Case		Tonnes/Week	Churchill Proportion of Total Flow Through Atlantic Seaboard Ports
Base Period	(12 weeks)	46,000	5.1%
Case 1	(20 weeks)	65,000	7.1%
Case 2	(20 weeks)	75,000	8.2%
Case 3	(20 weeks)	85,000	9.3%

Churchill's share of projected increased wheat and barley production to 1990 (over the base period) in the eight crop districts in Northern Manitoba and Saskatchewan (5,074,000 tonnes combined), assuming a 20 week shipping season would be as follows:

Case 1 (65,000 tonnes/week) - 25.6%
Case 2 (75,000 tonnes/week) - 29.6%
Case 3 (85,000 tonnes/week) - 33.5%

It can be seen that even with a maximum season at Churchill (20 weeks total) the 85,000 tonnes/week flow rates could be achieved by allocating to Churchill only 33.5% of the projected increase in total flows (1990 over the base year) from the eight crop districts. Therefore, it would appear that the additional grain required for Churchill to operate at the present demonstrated capacity over a 20 week shipping season could be provided by increased production in Northern Manitoba and Saskatchewan and would still leave two-thirds of the projected growth to contribute to increased flows through Thunder Bay and other Eastern Ports. Flows of specific types and grades of grain might be affected more markedly, of course, and impacts would vary if levels of growth in grain production and sales differ from those projected.

1.3.4 Season Extension Strategy Alternatives

The alternatives examined were selected on the assumption that, during the limits of the historic 12 week season, the Port and elevator facilities would remain in operation much as at present except that the projected seasonal throughput of 888,000 tonnes would be achieved. This corresponds to a weekly flow of approximately 75,000 tonnes or two to three deep sea vessel loads per week. This level of activity is set as the base level.

Season Extension Early Summer

As discussed more fully in Chapter 4 unassisted vessels experience delays during the normal season in some years due to heavy concentrations of first year ice en route. If the season is to be advanced, it will be necessary to provide icebreaker support en route particularly in years of heavy ice. Under such ice conditions, icebreaker escort would be provided in areas of heavy ice while under light ice conditions, icebreakers would provide standby service on an individual vessel basis at critical locations. The level of service to be provided would be based on a trade-off between the cost delay to the vessel and the cost of providing ice breaker assistance. The costs of these services are included in the economic evaluation as described in Chapter 7.

Season Extension - Late Fall/Early Winter - En Route

There are three possible methods of navigation in the late fall and early winter depending upon the degrees of new ice formation.

a) In the earliest few weeks of season extension: unescorted navigation by unstrengthened or suitably ice strengthened vessels.

b) As ice thickness conditions increase: standby icebreaker service at critical areas.

c) With heavy concentrations of ice of greater thickness: full icebreaker escort service.

The transition from one alternative to another is determined by trade-offs between the costs of delays to the vessel and the costs of icebreaker services.

Season Extension Early Fall - Churchill Harbour

The first ice to form in Churchill harbour is fresh water slush ice. This ice usually clears the harbour and is then followed by the formation of fast ice.

The slush ice problem has been aggravated by the fact that the existing Ports Canada tug (Twolan) does not have adequate power to turn vessels at the wharf under heavy ice conditions. This sometimes results in shipping delays, but has not generally been the primary factor leading to closure of the Port. The limiting factor has been the draft limitation in the tug's winter berth which has restricted entry to periods of maximum high tide. In most years therefore, tidal cycles rather than ice formation have determined the end of the season.

During the course of the study, Ports Canada approved the purchase of a new tug which will have adequate capacity to provide the necessary assistance to vessels during slush ice conditions. Also, the new tug will have a shallower draft than the Twolan and has a flat-bottomed hull so the timing of its drydocking for winter storage is no longer significantly constrained by tidal cycles. The new tug also has more power so that it can cope with more ice during its winter berthing process.

The alternatives examined for season extension at the harbour include:

a) Use of the harbour tug to keep the wharf area open

under ice thicknesses of up to 15-30 cms as is the practice at some Canadian harbours.

b) Use of ice management equipment such as an "ice filter" to control rate of ice formation in the wharf area.

c) Use of icebreakers to keep the harbour area and its approaches navigable.

d) Relocation of Port facilities to salt water.

These strategies and related requirements and findings are described more fully in Chapters 3 through 6. Before addressing them, Chapter 2 provides an assessment of the capability of the rail line serving Churchill and the matching capability of the elevator and Port in terms of grain throughput, with particular reference to demonstrated capacity and season extension requirements.

2. RAIL LINE AND ELEVATOR/PORT THROUGHPUT CAPABILITY

2.1 THE EXISTING RAILWAY

The main railway line serving Churchill was constructed in two stages. The first stage from Hudson Bay, Saskatchewan to The Pas in Manitoba was built between 1906 and 1910. Construction of the second stage from The Pas to Churchill commenced in 1911 and was completed in 1929. The line, illustrated in Exhibit 2.1, is single track and has a total length of approximately 950 km; the total length of the three subdivisions joining The Pas to Churchill is about 816 km.

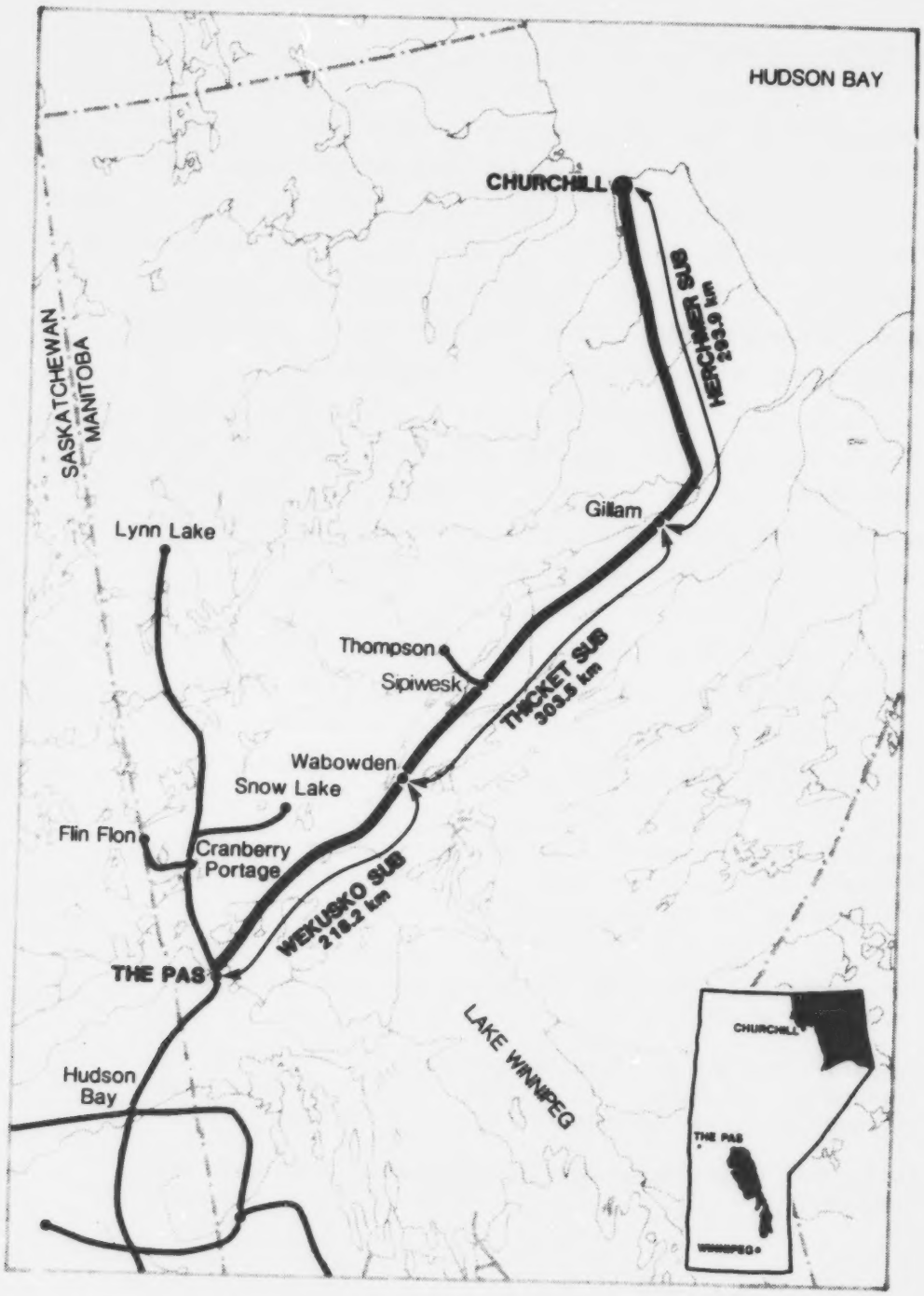
Prior to 1958, the railway was operated by CN as a separate federal government service but it was financially integrated into the CN system at the time of full scale development of the International Nickel Company facilities and town site at Thompson, Manitoba.

While grain for export is currently the principal freight transported on the line, it also accommodates other important services benefitting Northern Manitoba communities and the Keewatin district of the Northwest Territories. These services include the following:

- general and commodity freight services to the mining centers of Flin Flon, Lynn Lake, Snow Lake, Cranberry Portage and Thompson;
- freight services for hydro-electric facility developments along the Nelson River and the support community at Gillam;
- general freight services to the Churchill community and resupply freight for those Arctic communities resupplied by air and water transport from Churchill;
- VIA Rail services operating between Winnipeg and Churchill.

exhibit 2.1

CHURCHILL RAILWAY SYSTEM



During the Second World War and until recently, the railway supported a key military airbase and airport located at Churchill. The military base has been abandoned and the airport is now operated by Transport Canada. There is discussion of reopening military activity at Churchill in terms of possibly basing CF-18 fighters or a USAF AWACS aircraft there.

Historically, the railway has played a significant role in the transport of grain for export, but its relative importance in this context diminished with the growth of Canadian grain markets in Asia and with the opening of the St. Lawrence Seaway in 1959. While there is now a road as far as Gillam, the railway is still relied on for moving heavy supplies (i.e. cement, steel, prefab housing) to Gillam for construction at hydro electric power facilities on the Nelson River.

The railway has also played a key role in the development of mining and hydro resources in Northern Manitoba. Its importance in these respects has lessened as a result of road construction and improved air services within the region. The railway remains as the only land link to the Town of Churchill and the Port, and it is the principal transporter of freight to that community, both for local use and for resupply of the Arctic communities to the North.

The Herchmer Subdivision (293.9 km of line between Gillam and Churchill) is classed as a grain dependent line[1] and is believed to be the only main line railway in Canada that is so designated. The CNR has also requested that the adjacent Thicket Subdivision (303.5 km in length) be designated as a grain dependent railway.

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1. Generally applied to Prairie branch lines on which grain constitutes 60% or more of the originating or terminating traffic. This qualifies the line for possible federal branch line rehabilitation subsidies.

Initially, the railway was constructed with rail weighing 80 lbs./yd., but by the early 1980s this light rail was replaced with 100 lbs./yd. rail. The relative load bearing capacity of commonly used rail types is shown in the following table:

Comparison of Rail Load Bearing Capacity

Weight of Steel Rail (lbs./yd.)	Maximum Loaded Car Weight (lbs.)	Grain Car Carrying Capacity (tonnes)
80	177,000	60 tonne box car
80 to 100	220,000	90 tonne aluminum hopper car
100+	263,000	100 tonne steel hopper car

Installation of the heavy rail has not resulted in an increase in load bearing capacity, as anticipated. This is due to poor subgrade conditions along significant lengths of the line, particularly on the Thicket and Herchmer Subdivisions. Here, the railway has been built upon discontinuous areas of frozen soil or permafrost. Thawing of the permafrost layers results in differential settlement which, in the opinion of the railway, significantly increases the risk of derailment of empty hopper cars (due to resonant frequency swaying of the hopper cars related to their long wheel base) and also may require carloading limitations to reduce line settlement. As a consequence, use of the railway is restricted to boxcars which currently carry approximately 55 tonnes of grain although they have a nominal capacity of 60 tonnes.

The railway has identified a substantial number of "sinkholes" on the line: locations prone to subsidence on thawing of the top layers. As described more fully in Study D, an engineering study has been carried out which states that cryostatic devices ("cryo-anchors") could be installed to prevent summer thawing of the sinkholes and thereby remove or greatly reduce the subsidence problem. The report estimates a capital cost of $15

million to upgrade the line in this manner so that it would be capable of carrying conventional hopper cars. Railway officials point out, however, that there are large uncertainties in this situation since there may be more sinkholes than currently identified and the cryostatic technology is not fully proven, such that the cost of the line upgrading might be double the above estimate and there is no guarantee that the upgraded line would be able to carry fully-loaded grain hopper cars. CN is currently conducting surveys to pinpoint trouble spots as part of the Canada/Manitoba Subsidiary Agreement on Churchill.

2.2 GRAIN DELIVERY SYSTEM CAPACITY

2.2.1 Rail System

The capacity of the grain delivery system to the Churchill terminal is determined by:

- the capacity of the rail line and yard, including equipment availability;
- the practical unloading rate of the grain car dumpers;
- the throughput rate of the elevator to vessels.

The cleaning capacity of the elevator can also be a constraint.

In the longer term, there could also be a problem with grain car availability. At present, the line can only accommodate grain cars of the boxcar type as noted above. The supply of grain boxcars is dwindling as they are wearing out and being replaced by hopper cars. This issue is addressed more fully in Study D and is discussed further at the end of this chapter in the context of season extension.

The capacity of the rail line and Churchill rail yard is a function of the number of trains which can be accommodated over the

shipping season, the number of cars in each train and grain car capacity. The critical element in the line capacity is the Thicket and Herchmer Subdivisions, principally because of current restrictions in effect on gross car weights because of the subgrade problems referred to above. At present, the subdivisions have an adequate number of long sidings to accommodate nine or ten 160 car grain trains weekly in addition to other normal summer traffic on the line. This represents a weekly throughput of up to 88,000 tonnes. The Churchill yard has room for 1,500 boxcars and CN officials interviewed as part of this study also indicated that up to 250 cars per day can be unloaded, which would be equivalent to a weekly throughput of up to 96,000 tonnes. Based on these numbers, the rail line and yard are capable of delivering up to 1,056,000 tonnes during a 12 week season and proportionately more in an extended season.

The Hall Commission in 1977 referenced previous studies which estimated the line capacity at 30 million bushels over the shipping season. This is equivalent to about 820,000 tonnes (wheat equivalent) assuming the Statistics Canada conversion rate of 36.7 bushels of wheat per tonne.

Since 1977, there has been an increase in net car loading weights on the line of approximately 10 per cent resulting from upgrading of the line (see Exhibit 2.2). The same number of cars as used in the 1977 estimate could currently deliver approximately 900,000 tonnes of grain in a 12 week season. The Commission also made reference to an estimate provided by the Port Churchill Development Board which indicated that the line could deliver 55 million bushels of grain (1.5 million wheat equivalent tonnes) during the shipping season, assuming the line were upgraded to safely carry fully loaded hopper cars and additional long sidings were constructed to accommodate additional trains. These estimates of capacity are presented as background to the actual delivery capability experience discussed below.

exhibit 2.2

AVERAGE GRAIN CAR LOADINGS (TONNES)

TERMINATION OR DESTINATION POINT	1974	1977	1980	1982
Thunder Bay (CN)	51.2	57.3	60.6	62.6
Thunder Bay (CP)	57.3	64.3	65.8	67.9
Armstrong (CN)*	51.2	48.4	53.1	-
Churchill CN	47.9	50.5	50.9	55.0***
Churchill CN/CP			52.3**	

* Armstrong is designated as the point of rail delivery of eastern transfer export grain

** A special shipment in CP boxcars from Saskatoon area to Churchill

*** Estimate

Source: 1974, 1977 and 1980 data : Snavely King and Associates, January, 1982

1982 Data: Grain Transportation Authority, Increasing the Proportion of Hopper Cars in West Coast Service, July, 1982.

Grain Transportation Authority, Rail Boxcar Capacity and Requirements to 1991, July, 1983.

Ports Canada officials at Port Churchill in October, 1985, indicated to the IBI Group that the rail, elevator and Port system has the demonstrated capability to regularly accommodate 8 trains weekly, each train having 160 cars with 55 tonne payloads. This flow is equivalent to a seasonal throughput of 855,000 tonnes in a "normal" 85 day season. To put this in context, many single track lines in Canada routinely carry 25-30 trains per day (both directions) while the above flow in the Churchill line is slightly more than two trains per day (both directions), including the VIA Canada passenger trains and other freight trains which use the line as described in Study C.

In the following sections, the evidence regarding the capacity of the rail line and yard, rail/elevator interface and elevator processing and ship loading system is presented primarily by describing and analyzing actual volumes achieved during years of high throughput and relating these to current conditions. This is then used as the basis for assessing the rail delivery capability in an extended season and for carrying out the cost benefit analysis of various durations of season extension under several feasible flow levels.

2.2.2 The Year 1976

The 1976 season was a near record for the Port of Churchill for grain shipments. System operating statistics for the year were documented in detail and form the most comprehensive data base available for analyzing system performance and capacity. During the year 383,300 tonnes of wheat, 311,500 tonnes of barley and 24,300 tonnes of screenings and pellets were loaded to vessels for export. The total export throughput (719,100 tonnes of grain, screenings and pellets) was carried in 27 vessels.

The vessels were loaded on 78 of the 79 shipping days and the average daily discharge rate to vessels was 10,360 tonnes. The 27 vessels each spent an average of 8.7 days in Port. During the period from

September 28 to October 5, there were between 5 and 6 vessels in Port (or anchored nearby) daily. This congestion led to above average daily discharge rates and, over the 7 day period October 4 to October 11, these averaged 16,500 tonnes daily. A smaller loading peak occurred from September 7 to September 14 when an average daily discharge rate of 14,000 tonnes was achieved. The average rate for the combined periods was approximately 15,000 tonnes daily and is equivalent to seasonal throughput of 1.28 million tonnes if the rate were sustainable over the full 85 day season. The discharge system has a nominal working capacity of 1,200 tonnes per hour and a productive capacity of approximately 1,000 tonnes per hour on a sustained basis. The loading rate of 15,000 tonnes per day implies 12 to 12.5 hour average daily operating shifts during peak periods. The daily sustainable discharge rate (20 hour period) would be 20,000 tonnes.

The peak throughput for the cleaning equipment was 29,188 bu./hour (about 800 wheat equivalent tonnes per hour). Twenty-four hour operation of the cleaners would produce approximately 19,000 tonnes of clean grain daily. This was for approximately equal throughputs of wheat and barley which were handled by the Port in 1976. At 20 hours per day, a practical operating period over a season, the cleaning capacity of the elevator would be about 16,000 tonnes daily.

The nominal receiving capacity of the elevator is fixed by the combined capacity of the four car dumpers and receiving scales. These dumpers can dump 20 cars per hour in total which, assuming an 85 day season, 20 hour working days and 55 tonne carloads, results in a nominal capacity of 1.61 million tonnes (assuming a 6 day work week) or 1.87 million tonnes assuming a 7 day work week. During the peak 15 day receiving period in 1976 the receiving capacity was demonstrated to be 36,391 bu./hr., equal to approximately 990 wheat equivalent tonnes per hour. With the current 55 tonne carloads the capacity would be approximately 1,100 tonnes per hour. This corresponds to a daily capacity (20 hour work day) of 22,000 tonnes. One shift operation with operating

as required (8-12 hours per day) is current practice at Churchill, but elevator and Port officials stated that two shift operations (16-20 hours/day) would be feasible without the need for more capital investment.

The demonstrated capacity of the elevator system is therefore approximately 20,000 tonnes per day based on 20 hours of operation per day. At present, the elevator operates in a single shift basis. Overtime work is possible provided that the owners of the ship being loaded are prepared to accept the extra costs involved.

During the period July 1 to October 11th, the elevator received 14,493 cars in 105 trains. The average train length was 138 cars. Trains were received on a total of 79 days, resulting in an average of 1.33 arriving trains on each day on which trains operated. The longest sustained delivery period was 22 days, during which 4,218 cars were delivered for an average of 192 cars/day.

During the season, there were four sustained car arrival surge periods each lasting 7 days or more. Car arrivals during these periods were as follows:

Peak Daily Rail Car Arrival Rates

Period (7 days) (1976)	Number Box Cars		
	Total	Average Daily	Peak * Day
August 13 - 19	1,484	212	298
August 25 - 31	1,458	208	292
September 5 - 11	1,457	208	298
September 13 - 19	1,437	205	299
Average	1,459	208	297

* Absolute peak day - 300 cars

Assuming current 55 tonne carloads, the average daily demonstrated sustained peak delivery rate (7 day period) is 11,440 tonnes per day (80,000 tonnes per week) or 972,400 tonnes over an 85 day period. On the basis of the sustained 22 day rate, the corresponding annual capacity is 897,600 tonnes (about 74,000 tonnes/week). The highest throughput scenario considered in the economic evaluation of Chapter 7 (85,000 tonnes/week as noted earlier) would require sustained delivery of about 220 boxcars per day.

At the start of the shipping season there was 99,152 tonnes of grain in storage. This would increase the throughput capacity of the delivery system to between 996,750 and 1,071,550 tonnes on an annual basis, or 83,000 - 89,000 tonnes per week over a 12 week season.

In summary, the nominal capacity of the elevator system based on demonstrated throughput in 1976 is approximately as follows:

Cleaning	800 tonnes/hr.
Discharge to vessels (over 7 day period)	15,000 tonnes daily
Car dumping and grain receiving capacity	1,100 tonnes/hr. (55 tonne cars)
Rail delivery-no prestorage (85 day season)	898,000 to 972,000 tonnes
- with 100,000 tonnes prestorage	998,000 to 1,072,000 tonnes

Discussions with elevator officials indicated that equal or greater car dumping and grain receiving capacity could be achieved if regular or articulated hopper cars were used, although modifications to the receiving equipment would be required to take full advantage of the greater unloading productivity of these cars.

The above railway capacities are believed to be near the limit of the existing system assuming no serious breakdowns or other non-scheduled interruptions in service. The seasonal throughput capacity of the

remaining elevator components are tied to hours of operation. The maximum weekly throughput would be achieved with 120 hour working of the dumpers and vessel loading equipment (about 17 hours per day) and 144 hour weekly operation of the cleaning equipment (about 20 hours per day).

2.2.3 The 1977 Experience

In 1977, 814,000 tonnes of Board grain and dockage were delivered to Churchill in 16,096 box cars and 755,200 tonnes of grain, screenings and pellets were exported through the Port. The average load per train was 3,803 tonnes and train lengths averaged 84 cars.[2] The average number of trains weekly, assuming an 85 day shipping season, was 16. The same number of cars and trains could have carried 895,000 tonnes under current allowable loads of 55 tonnes per box car.

2.2.4 Summary of Rail Line and Elevator/Port Throughput Capacity

Estimates of the delivery capability of the existing rail system are summarized in the following table:

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2. Snavely, King and Associates, 1980 Costs and Revenues Incurred by the Railways in the Transportation of Grain under the Statutory Rates, January 1982.

Summary of Churchill Grain Delivery System Capacity

Source of Base Data Used in Estimates	Year of Estimate or base year	Reported Capacity (tonnes)	Adjusted Annual (tonnes)	Capacity* Weekly (tonnes)
Hall Commission	1977	820,000	902,000	74,300
Typical Recent Volumes Levels as Reported by Ports Canada Churchill Staff	1985	855,000	855,000	70,400
Canada Grains Council (Actual)	1976	840,000 - 882,000**	924,000 -970,000	80,000 -84,000
Snavely, King & Associates (Actual)	1982	814,000	895,000	73,700

* Assuming 55.0 ton carloads and 85 day shipping season.

** Annual capacity based on demonstrated performance over 15 day period was 882,000 tonnes, equivalent to a capacity under current car loadings of about 84,000 tonnes per week.

Capacity estimates for transportation systems and their elements cannot usually be made on a rigorous or exact basis because of the large number of factors which affect capacity levels. The safest course of action, if possible, is to base such estimates on actual performances under various circumstances, and this is the course adopted here, as summarized in the above tables. The table and related data presented demonstrate that volumes of 70-75,000 tonnes per week are routinely handled and higher volumes of 80-85,000 tonnes per week can be carried over periods of 2 or 3 weeks. It is the study team's conclusion, based on analysis of the system and discussions with railway, Port and elevator staff, that these volumes would be sustainable over a 12 week season or an extended season of up to 20 weeks (see also section 2.4 below) with appropriate workshift arrangements. Any incremental capital investments

which might be found desirable to sustain the higher levels of throughput (e.g. more yard trackage, future modification of receiving equipment to take hopper cars) would be recovered through increased revenues from the higher throughputs as described more fully in Study D, so that they are not treated as special costs for Churchill, but rather as normal investments recovered through the rate structure. A similar approach is taken in Chapter 7 of this report.

By storing grain in the elevator in advance of the shipping season, all annual capacity estimates could be increased by approximately 100,000 tonnes. This practice of pre-season storage of grain at Churchill in the fall was followed in the past, but in recent years the practice has been increasingly discontinued by the CWB, or replaced by pre-season loading in the spring, because of the marketing risks involved as noted earlier in sub-section 1.3.3.

2.3 THE COUNTRY GRAIN RECEIVING SYSTEM

2.3.1 Receiving Points

The number of railway receiving points for grain in Western Canada has declined steadily as a result of system consolidation. This decline has resulted in significant improvements in productivity per receiving point measured in terms of annual car loadings at individual points. The reduction in receiving points in the three Prairie provinces is illustrated by the following statistics:

Year	Number of Receiving Points
1974	1,658
1977	1,517
1980	1,295
1984	1,155

The distributions of receiving points on the basis of their weekly car loadings for the years 1974, 1977 and 1980 are shown in Exhibit 2.3. The data shows a steady decline in the number of points loading less than 300 cars annually. There has also been a significant increase in the total number of cars loaded annually, attributable to the growth in grain production.

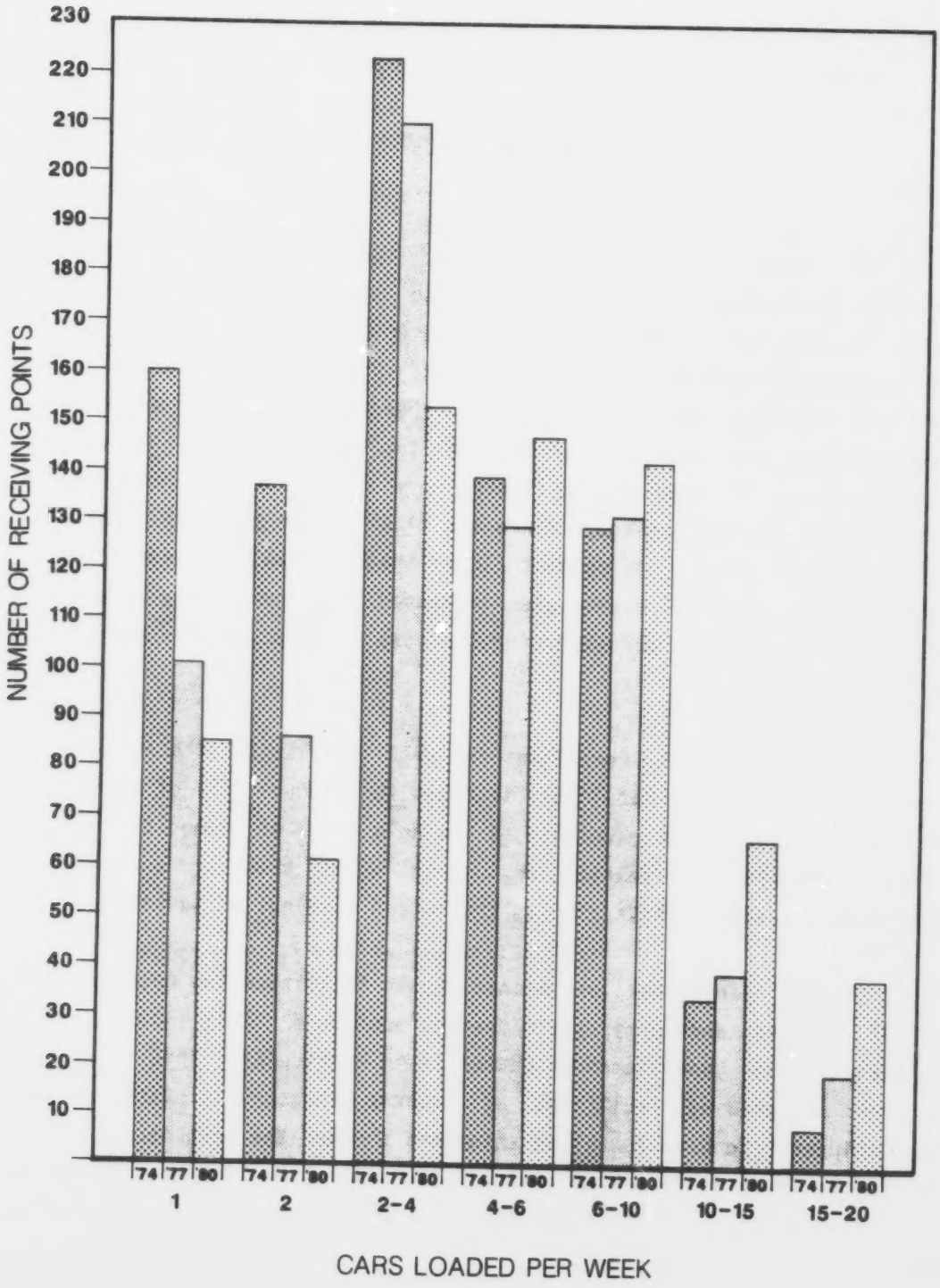
As demonstrated in Exhibit 2.4, there has been a strong shift from less productive receiving points to more productive ones. For example, in 1974, 81 percent of total system car loadings were at points loading less than 6 cars in an average week. By 1980, this percentage had decreased to about 66 percent. The changes on the CN system were marginally less, decreasing from about 83 to 68 percent. The improvement in productivity of the points is even more significant when measured in terms of throughput tonnage, since the flow through the total system in 1980 was approximately 45 percent higher than in 1974. The average size of carloads in the total system also increased by approximately 15 percent over the period, with a corresponding increase of about 10% for deliveries to Churchill.

Delivery points consolidation will facilitate the assembly of grain trains, but will not likely increase the productivity of assembling unit trains (trainload movements of a single grade of commodity from the loading point to the destination point) unless these are assembled at major country loading points such as the inland terminal at Saskatoon.

Fewer, larger delivery points should facilitate the decentralization of protein and other grain grading equipment. This should benefit all exports and those through Churchill in particular. This is because the lack of grading facilities at country elevators is stated by some grain shippers to have inhibited shipments through the Port because it is seen to be more difficult to dispose of grain not meeting specifications there than at larger terminals which normally handle orders for a wider range of grain types and grades.

exhibit 2.3

DISTRIBUTION OF GRAIN RECEIVING POINTS
CN SYSTEM



SOURCE: Snavely, King and Associates, 1980 Costs and Revenues Incurred by the Railways in the Transportation of Grain Under the Statutory Rates, January 1982.

IBI GROUP

exhibit 2.4

WEEKLY CARLOAD THROUGHPUTS STATUTORY GRAIN GRAIN RECEIVING POINT SYSTEM 1974 AND 1980

Average Weekly Carloads	Per Cent of Annual Statutory Grain Throughput			
	CN System		Total System	
	1974*	1980	1974	1980
Less than 6	84%	68%	81%	66%
6 to 15	16%	28%	18%	29%
More than 15	1%	4%	1%	5%
Total	100%	100%	100%	100%

* 1% rounding error in original data

Source: 1980 Costs and Revenues incurred by the railways in the transportation of grain under statutory rates.

Snavely, King and Associates, January, 1982

2.3.2 Loaded Miles to Terminals

The average loaded miles of actual shipments in 1980 from country elevators to the destinations/terminals in the CN system were as follows (CP distances in brackets where applicable):

Destination/ Terminal	Distance (miles)
Armstrong and East	971
Thunder Bay	861 (865)
Churchill	825[3]
Prince Rupert	1,375
Vancouver	954 (901)

Churchill has a small advantage over Thunder Bay in this respect.

2.3.3 Rail Car Loadings

Statutory grain loadings at the CN country delivery points by car type in 1980 were as follows:

Boxcars	47.1%
Railway Hopper Cars	2.4%
CWB Hopper Cars	50.5%
Total	100%

All grain to Churchill was and continues to be shipped in standard boxcars. The average carloads shipped to each destination are shown on Exhibit 2.2, as noted earlier.

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3. A special shipment from CP points via Saskatoon involving average shipping distances of 923 miles is included in the Churchill figures.

The average loads of statutory grain by type of car in 1980 were:

	Tonnes		
	CN	CP	Combined
Boxcar	51.4	56.5	53.9
Railway Hopper	66.1	63.4	64.6
CWB Hopper	72.9	79.5	76.0
Average (all types combined)	60.8	66.0	63.0

The current average loads for Churchill boxcars are 55 tonnes. As more grain boxcars are scrapped, the proportionate utilization of large capacity hopper cars on competing routes will increase and the relative disadvantage of Churchill will increase. Introduction of the proposed 94 tonne articulated hopper cars would decrease the number of cars required, but might not significantly increase average train loads from the current nominal level of 8,800 tonnes (160 boxcar trains). The average weights of trains on all CN systems, as shown in Exhibit 2.5, suggest that the average for Churchill is quite similar to those to other ports.

2.4 RAIL AND ELEVATOR/PORT THROUGHPUT CAPABILITY AND COSTS: EXTENDED SEASON

The evidence presented earlier in this chapter shows that the combination of the rail line to Churchill, the Churchill railyard, the rail/elevator interface, elevator cleaning/grading and loading from elevator to ship is routinely capable of handling 70-75,000 tonnes per week and has demonstrated its ability to deliver higher volumes (80-85,000 tonnes per week) over two to three week periods during years of high throughput (e.g. 1976, with results updated based on current carloadings). It was noted that the critical elements of the system are the car usage restrictions (which currently preclude the use of conventional hopper cars) on the Thicket and Herchmer Subdivisions of the rail line (owing to unstable permafrost conditions) and, related to this, attrition in the number of available grain boxcars which may begin to

exhibit 2.5

AVERAGE WEIGHTS OF TRAINS CARRYING DIRECT SHIPMENT STATUTORY GRAIN (TONNES)

Destination	1974	1977	1980
Armstrong & East (CN)	3,499	3,600	4,100
Thunder Bay (CN)	3,470	4,246	4,506
Churchill (CN)	3,081	3,803	4,136
Prince Rupert (CN)	2,884	3,193	4,038
Vancouver (CN)	3,538	3,843	4,352
CN System Average	3,396	3,992	4,366
CP System Average	4,482	4,886	4,751

SOURCE: Snavely, King and Associates, 1980 Costs and Revenues Incurred by the Railways in the Transportation of Grain Under the Statutory Rates, January 1982.

cause capacity limitations on Churchill deliveries during the 1990's unless additional boxcars can be obtained (i.e. from CP and from U.S. railroads).

As pointed out in Study D, there are three basic strategies which could be adopted to address this combined problem:

1. Rehabilitate enough boxcars to maintain the required number for Churchill deliveries;

2. Construct enough articulated (94 tonne) hopper cars to serve Churchill, if the prototype car now under testing by CN proves practical;

3. Upgrade the rail line so that conventional hopper cars can be accommodated.

A preliminary economic assessment of these three alternatives is carried out in Study D, which suggests that any one of the three alternatives could be the most cost-effective, depending on assumptions regarding the lifetime of rehabilitated boxcars and the availability of CP boxcars for use to Churchill, the practicality and cost of articulated hoppers, and the success and cost of the proposed "cryo-anchors" approach to stabilizing the permafrost underpinnings of the rail line. There are substantial uncertainties regarding the most appropriate assumptions to be used in assessing the economics of each of the alternatives, such that it would be premature to state unequivocally at this time that one of them is superior. More evidence regarding at least some of the above uncertainties will become available from the testing of the articulated hopper car (on which a report is to be completed in early spring, 1986) and a decision on the appropriate course of action will benefit from such evidence.

For purposes of assessing rail capability and costs to serve an extended system at the Port of Churchill, we use the existing system, including the availability of sufficient boxcars, as applicable in the

period to 1990 and we provide a more general discussion of a subsequent period to the year 2000 in the face of the above uncertainties.

2.4.1 The Existing System to 1990

The rail line has served the Port of Churchill for some 55 years on an all year basis. Discussions with officials of CN, the elevator and the Port of Churchill, and statistics regarding the timing of deliveries to the Port, indicate that grain deliveries have routinely been made outside of the normal 12 week season (and general cargo/passenger services are offered during the full year as noted earlier) and that no reductions in rail capability or increases in costs would be anticipated for grain deliveries in the season extension periods under consideration (e.g. a possible seven week fall extension to early December and a possible three week spring extension to early July). Indeed, the fall freeze-up tends to improve operating conditions by stabilizing the subgrade of the line, such that operations during November and December are likely to be more trouble-free and less costly than those during the summer. While line instability problems are likely to be more severe in the spring, these are likely to have already been addressed (in order to serve normal all-year traffic) by early July which is the earliest feasible season extension owing to ice constraints in Hudson Bay, as described more fully in Chapter 4.

It is therefore concluded that the rail capacity and cost data which apply to operations in the normal 12 week season are also applicable for potential extensions of up to seven weeks in the fall and up to three weeks in the spring. More details on the costs used are presented in Chapter 7. The economic impact of three alternative levels of grain throughput (65,000, 75,000 and 85,000 tonnes per week as described earlier) are also shown in the cost benefit analysis presented in Chapter 7.

2.4.2 The Future System 1990 - 2000

As pointed out above, if Churchill is to continue and possibly expand as a grain exporting outlet, one or more of the three alternative courses of action outlined earlier (rehabilitated boxcars, articulated hopper cars, upgrading of the rail line to take conventional hopper cars), will have to be taken.

For purposes of assessing rail and elevator/Port capability and costs during an extended season, it is the study team's judgement that, regardless of the approach which is ultimately taken, the same conclusions will apply as stated in the previous subsection. That is, the delivery capacity and cost/effectiveness of the rail line will be at least as high during the potential season extension periods under study, as it will be during the normal 12 week season.

Since the uncertainties regarding the future improvements to rail equipment and/or the rail line are so great at this time, it would not be productive to carry out cost-benefit analysis of season extension for the hypothetical future conditions which might apply. It is reasonable to conclude, however, that the cost-effectiveness results for the present system operating in the period to 1990 are representative also for the future period to the year 2000, since any additional investments in the rail system will have been made basically in function of the normal 12 week season (as discussed more fully in Study D) and rail system capability/costs for the future system will be at least as high in an extended season as in the normal season.

2.4.3 Conclusions

Two important conclusions are highlighted from this chapter:

1. Weekly rail and elevator/Port system capacities of 65,000 tonnes, 75,000 tonnes, and 85,000 tonnes, are achievable by the existing system (with additional shift operations as appropriate) and the range of throughputs so represented should be used in the cost-benefit assessment of season extension in order to demonstrate the sensitivity of the economics of season extension to the volume of grain available. As noted earlier in the chapter, the middle of these three values (75,000 tonnes per week) is equivalent to the "base" forecast of 888,000 tonnes per year adopted for this study, based on the projection of grain volumes to 1990 carried out by the Canada Grains Council in 1982. An important reason for studying alternative throughput levels both higher and lower than the base estimate is that normal market forecasts do not apply for the Port of Churchill since grain throughput there is directly controlled by the CWB and is, therefore, a matter of policy and sales programs as decided by that agency;

2. The available evidence from both operating experience and the opinions of railway and other officials indicates that the capability and cost-effectiveness of the rail line and railyard serving the Port of Churchill and of the elevator and Port facilities, will be at least as high during the season extension periods under study as it is during the normal season. It is therefore appropriate to use the same capacity and cost figures for the extended season as for the normal season, as these relate to the rail and elevator/Port facilities, with some cost increases as season extension becomes longer (see Chapter 7).

Accordingly, the economic analysis of season extension, as described in Chapter 7, is based on the above conclusions regarding the throughput capability and costs of the rail system serving the Port of Churchill and the elevator and Port facilities. The costs of additional shifts of operation for higher throughput levels are, of course, taken into account as described in Chapter 7.

3. SEASON EXTENSION IN PORT

Season extension implies the possibility of an extension at the beginning of the shipping season as well as at the end of the season. Presently, the harbour is open for coastal traffic in the spring at least a month before Hudson Strait becomes navigable; therefore, an earlier commencement of shipping is not contingent upon Port conditions and the issue of an earlier opening of navigation through Hudson Strait is therefore dealt with in Chapter 4 which deals with en route ice conditions and related season extension requirements. The emphasis in this Chapter is on extending shipping at the end of the season focussing on requirements in the Port.

Fall season extension has been analyzed on an incremental time basis, to establish what is implicitly required to facilitate Port operations later in the season, after the normal closing date of about October 18.

3.1 PORT FEATURES

The Port of Churchill, Manitoba (Exhibit 3.1), is located on the west coast of Hudson Bay, at the mouth of the Churchill River, at 58 degrees 47'N and 94 degrees 12'W. The Port facilities are located inside the River mouth, well protected from any sea and swells originating in Hudson Bay.

Churchill harbour is bordered on the east by a rocky peninsula, tapering to a blunt point at Cape Merry, and on the west by another rocky peninsula surmounted by Fort Prince of Wales. Fetch lengths and water depths within the river mouth do not produce waves or disturbances that affect shipping operations. Maximum tidal range is approximately 4.7 metres at spring tide.

Historically, conditions within the harbour have been greatly influenced by the freshwater flow of the Churchill River. However, recently flow rates in the Churchill River have been substantially reduced by Manitoba Hydro's diversion of waters from the Churchill to the Nelson

exhibit 3.1

CHURCHILL STUDY AREA

River. The diversion came into full effect in 1980 and, as a consequence, flows in the Churchill River dropped by over 80%, from an average of about 800 cubic metres per second to about 130 cubic metres per second. As described further in sub-section 3.2.6 below, the lower flow rates since the diversion have substantially reduced problems of fall ice formation in the harbour, such that season extension in the fall is now constrained more by en route ice conditions than by ice conditions in the harbour.

As shown in Exhibit 3.2 the wharf and elevator facilities of the Port are located on the east side of the Churchill River, about one kilometre south of Cape Merry. The main wharf is 843 metres long with five berths for ocean-going vessels of which the central three are grain loading berths. The original wharf was constructed in 1929 of timber cribs and extended both north and south in 1963 with similar construction. Berth water depths at low tide are:

- one 168m berth with 9.5m depth;
- three grain loading berths totalling 518m, with 9.6 to 9.8m depth;
- one 157m berth with 9.0m depth.

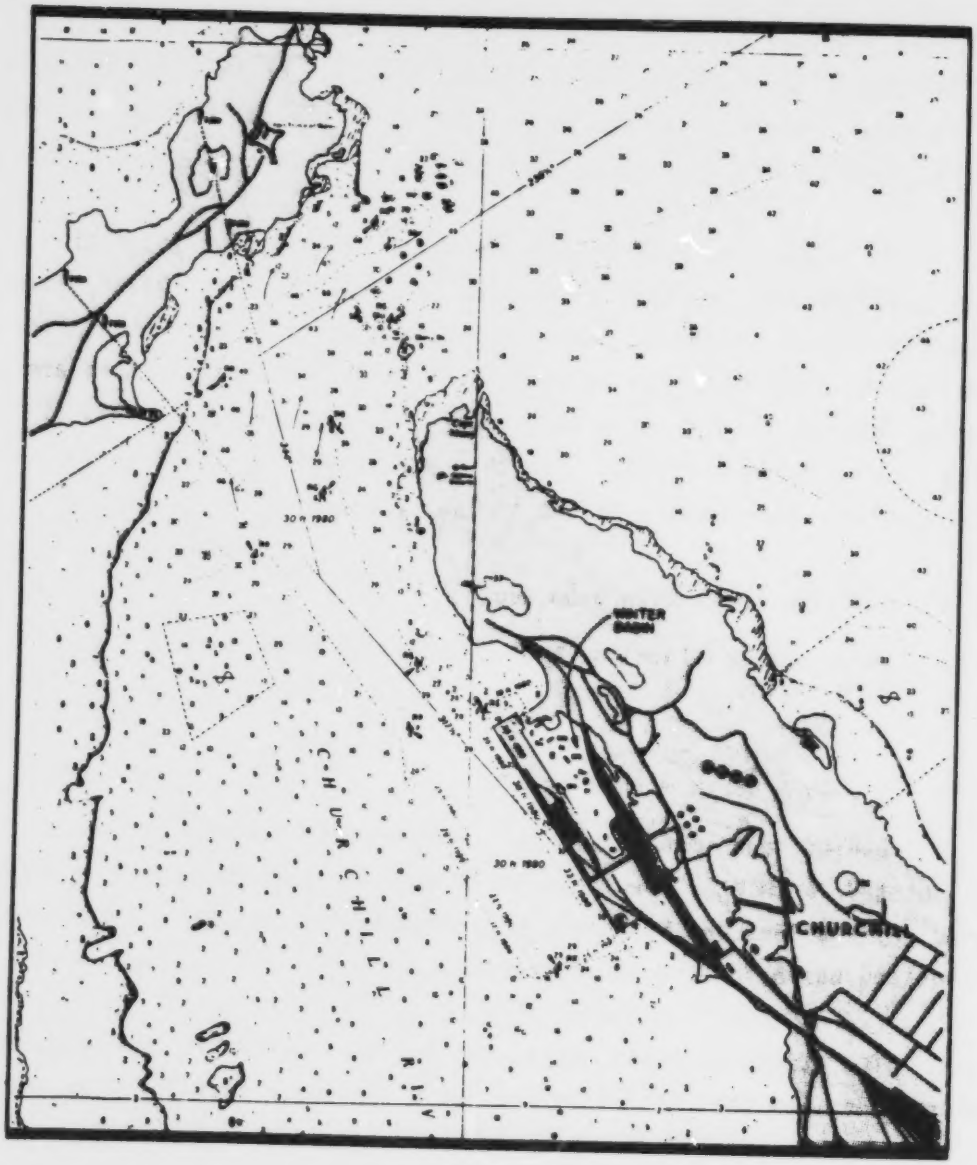
Behind and immediately east of the north portion of the main wharf is located a winter berth which is used to store the floating equipment owned by the Port and by Northern Transportation Company Limited (NTCL) in a tideless basin for the winter period.

The turning basin adjacent to the wharf is approximately 300 metres wide from the wharf face and had a low water depth of 9.2m in 1980.

Regular annual maintenance dredging was a requirement prior to the river diversion in 1980; since then only minor dredging of occasional large rocks and high spots has been done. There is an ongoing study into the sedimentation at the wharf now being carried out to quantify the

exhibit 3.2

CHURCHILL HARBOUR



SOURCE : STEVENSON HLUCHAN ASSOCIATES LIMITED

influence of the diversion on the harbour. Since the diversion, the flood tidal stream at the harbour entrance has a rate of about two knots and the ebb flow attains a rate of five knots. Surprisingly, the ebb flow is slightly greater now than prior to diversion.

Although the dates recorded for the port opening and closing were previously related to the harbour ice conditions, for the past five years (since diversion) the Port has been generally declared open and closed when the Port tug, the W.N. Twolan, departs from or arrives in the winter berth. The main dike for the winter berth is opened around the first of July and it is closed on the last high spring tide in October. Spring breakup of the river is generally around the first of June.

An exception to this practice was the occasion of late season loadings of the M.V. Arctic during the second week of November in 1979, and again in 1980.

Within the harbour, ice conditions at the season opening are generally clear. Tidal action has usually cleared the river mouth of the majority of the ice, although some smaller chunks may still remain. By the time the first ocean vessel arrives in late July there is seldom any ice within the harbour.

At the season closing the harbour is periodically covered with slush and grease ice and floes of brash and cake ice from about mid-October, with increasing regularity and thickness until it becomes fast ice some time in November. However, since the diversion of the Churchill River has come into effect, the early occurrence of slush and grease ice in the harbour has been substantially reduced, such that harbour ice is now generally not a significant constraint on operations before mid-November, effectively extending the fall season by about four weeks in terms of in-harbour conditions.

The monitoring of the condition of the Port facilities, including the elevators, is an ongoing port maintenance requirement. There are no apparent major problems; however, some settlement and movement of the wharf under the loading gallery had caused some concern when the berth was dredged deeper in 1979. This problem has now been rectified and there are no further significant movements reported.

The main maintenance item for the wharf is replacing timber facing damaged by winter ice. Otherwise, the wharf and marine facilities can be considered in fair to good condition.

3.2 CONDITIONS AND CONSTRAINTS

3.2.1 Port Operations

The primary function of the Port of Churchill is shipping Prairie grains. In the past ten years the number of vessels using the Port for overseas grain shipments has averaged 19 per year. The other vessels using the facilities are related to shipment of sulphur which was carried out on an experimental basis in 1974 and 1975 and resupply operations of the Northern Transportation Company Limited (NTCL), which makes about nine trips per year to the resupply ports in the Keewatin district of NWT, and other small cargo vessels with cargoes less than 40 tons going to the resupply ports as well. Other facility users have included oil exploration companies for drill ship resupply (ongoing at the present time) and incoming fuel shipments, (no longer made).

The Port of Churchill presently uses two tugs and the services of a pilot in order to aid and direct calling and departing vessels. The tug "W.N. Twolan" is a twin screw, single rudder vessel, powered by two 760 horsepower engines. The tug "George Kydd" is a 600 horsepower vessel. Both tugs are owned by Ports Canada. The "Twolan" carries a crew of eight and has accommodation facilities. It is capable of ocean travel and

normally draws around 3.7 metres. The "Kydd" is a much smaller vessel, carrying a crew of two or three and has no accommodation facilities.

Under the Canada/Manitoba Subsidary Agreement on Churchill, Ports Canada has agreed to construct a new 2,600 HP tug to replace the "Twolan", at a total cost of $2.7 million. The order for this tug has recently been placed and delivery is expected by July 1986. This more powerful tug is required in order to handle the larger vessels that more frequently use the Port. Although the new tug will draw 3.0 metres, almost one metre less than the "Twolan", it will not be capable of ocean travel and will carry a crew of only three, with no accommodation facilities. It has twin screws and twin rudders; as currently designed it will be ice-strengthened to Type C classification, capable of working in up to 15 cm of new ice and up to 30 cm of slush ice. The "Twolan" either will be used elsewhere by Ports Canada or sold. The "Kydd" will remain in operation in Churchill.

Calling vessels are generally met at the fairway buoy, a distance of about seven kilometres from shore, by the tug "Twolan". The pilot is transferred from the tug to the vessel and both vessels approach the harbour. If the weather is particularly bad, the pilot may be transferred much closer to the harbour or transferred by helicopter.

Large vessels always enter the harbour on ebb tide so that the current is against their rudders for better steerage while navigating through the narrows at the mouth of the harbour (see Exhibit 3.2). Once inside, vessels, still under their own power, berth against the Ports Canada dock, facing upstream. Usually on the next flood tide vessels are turned, facing the harbour entrance. The tugs "Twolan" and "Kydd" are used to turn vessels, with the help of the ebb tidal current.

The length of stay of vessels varies from a few hours in the case of the resupply tug "Keewatin" to ten or more days for some grain vessels. Grain vessels stay about five days on average although the

average stay has been longer in some years (e.g. 8.7 days in 1976, a year of high grain throughput)..

When vessels are ready to leave, the pilot goes on board and the tug "Twolan" assists departing vessels by pulling their bows away from the dock. Vessels leave the harbour under their own power and, once outside, the pilot is transferred to the tug.

Large vessels generally top up with cargo on the rising tide and sail before the tide begins to fall. This allows vessels to take on considerably more cargo, due to the three to four metre tides.

3.2.2 Port Closing

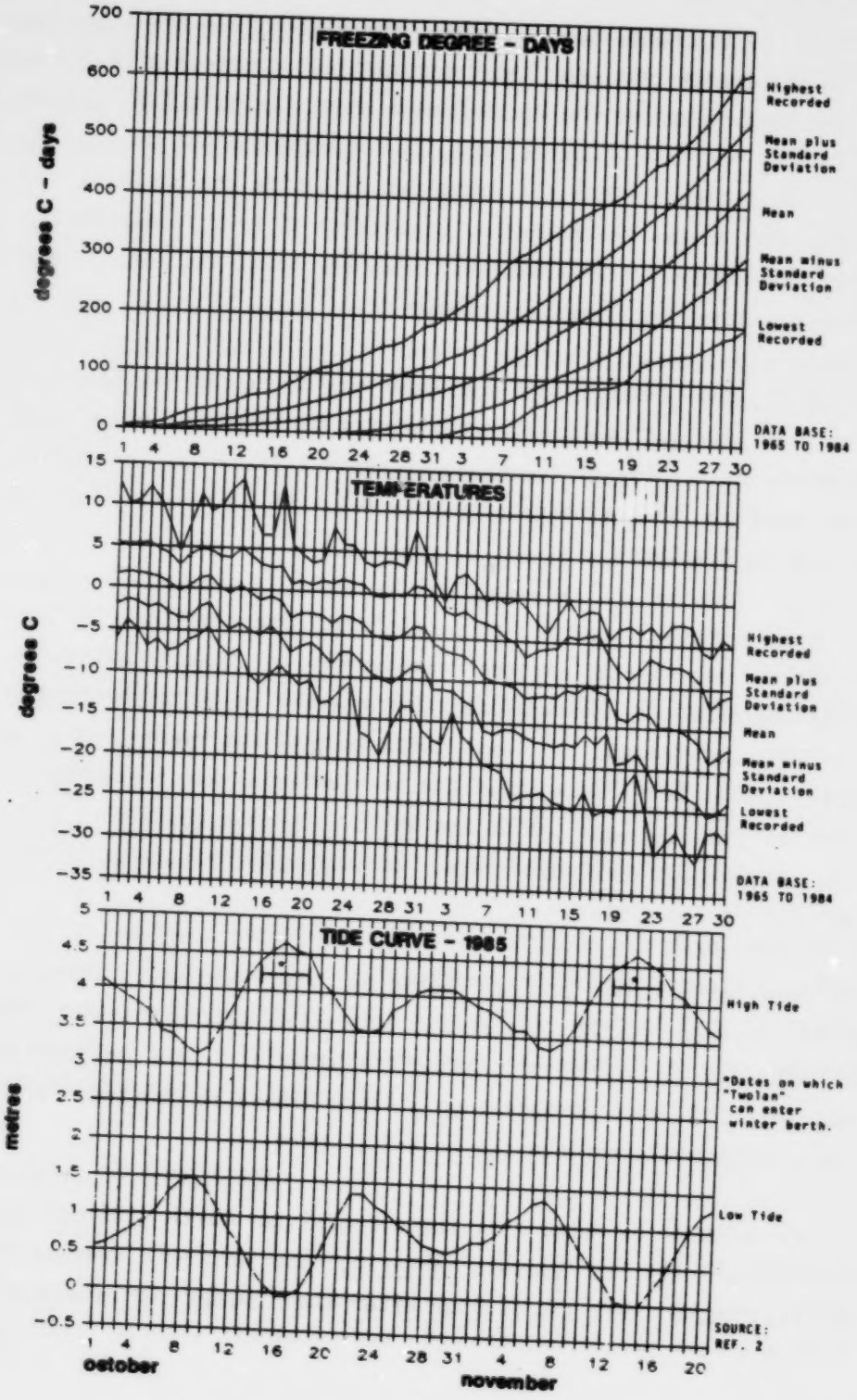
During the 1960's and early 1970's the Port was declared closed when solid ice formed across the harbour. These dates were reported in the Port's annual reports. More recently, the date of Port closing has been considered to be when the tug "Twolan" has been placed in the winter berth. This operation is scheduled to coincide with the latest "spring" tide (higher than normal tides which occur every four weeks) in October, as the high water is needed for the tug to gain access to the berth. This is often some weeks before solid ice forms within the harbour. Thus, although Port closing dates for recent years have been earlier, they do not suggest more severe early ice conditions. Environmental factors at Churchill, including degree-days below freezing, air temperatures and tidal curves, are shown in Exhibit 3.3

3.2.3 Winter Berth

At the end of the season, the Port tugs must be prepared for winter storage. The "Kydd" is small enough to be lifted out of the water by crane and placed on shore at any time. However, the "Twolan" is much too heavy to be removed by crane, and therefore must remain in water for

exhibit 3.3

ENVIRONMENTAL FACTORS : CHURCHILL, MANITOBA



SOURCE : STEVENSON HLUCHAN ASSOCIATES LIMITED

the winter. It must, however, spend the winter in a non-tidal basin or risk severe damage due to tidal fluctuations combined with ice action. Thus, the basin behind the Ports Canada wharf (Exhibit 3.2) is used as a winter berth for the "Twolan" and other floating plant used by NTCL for resupply operations. Once all equipment is inside the basin, a rock-fill berm is pushed across the entrance, separating it from tidal waters. This basin will eventually freeze at about mean sea level and remain frozen and unaffected by tides until spring breakup.

Until the new tug, with shallower draft, is commissioned, the date on which the "Twolan" must enter the winter berth represents a short-term but significant constraint to season extension. In 1985, for example, the "Twolan" entered the winter berth on October 18, the date of the highest spring tide in October.

Under present operating conditions, the physical closing of the Winter Berth represents another constraint to season extension. The rock-fill material that is used to close the basin can be handled only when it is not frozen. At least twice in the last twenty years, weather conditions have been such that the berm material was frozen by the time the "Twolan" was in place inside the berth. On both occasions, the frozen material could not be moved and, consequently, damage occurred to the "Twolan" during the winter.

Overcoming this problem should be relatively easy. Berm material could be covered during the season to prevent moisture from collecting, and/or possibly a method of heating the material in the cold weather may be devised. A more permanent solution would be to construct a stop-log type gate which would replace the rock-fill berm.

It should be noted that these tug/winter berth difficulties offer a restriction only to vessels <u>entering</u> the harbour. Vessels can, and historically have left the harbour after the "Twolan" is in winter berth.

Under these circumstances, the "Kydd" has been used to pull the bow of the vessel away from the dock before sailing. However, this would be possible only when there was relatively little ice in the harbour. This was accomplished this year (1985) when the last vessel left on November 2nd.

3.2.4 AWPPA

The Arctic Water Pollution Prevention Act (AWPPA) regulates the type of vessel (Exhibit 3.4) that can navigate in particular zones in the Canadian Arctic (Exhibit 1.2). Navigation to and from Churchill requires vessels to pass through Zone 14, Upper Hudson Bay, and Zone 15 (Hudson Strait and Cape Chidley). As described more fully earlier in sub-section 1.3.1, the dates by which the various types of vessels must leave Churchill in order to clear Zones 14 and 15 and the end of the season in accordance with AWPPA regulations are approximately as shown below:

Vessel Type	Approximate Churchill Leaving Date
Type A	November 28
Type B	November 26
Type C	November 21
Type D	November 6
Type E	October 29

The above Churchill leaving dates allow two days' sailing time to the eastern limit of Zone 14 (west end of Hudson Strait) and four days' sailing time to the eastern limit of Zone 15 (east of Cape Chidley). They could vary slightly from year-to-year depending on ice conditions, as described more fully in Chapter 4.

3.2.5 Ice Conditions

Ice formation within Churchill harbour often consist of a conglomerate of ice forms, generally referred to as new ice. This is ice which has recently formed, and is composed of ice crystals only weakly

exhibit 3.4

TYPES OF VESSELS USING THE PORT OF CHURCHILL

YEAR	GRAIN VESSELS	REGISTRY NOT AVAILABLE	NON-ICE STRENGTHENED	ICE STRENGTHENED	% ICE STRENGTHENED BY VESSEL ORIGIN*	
					ALL COUNTRIES	COMMUNIST BLOCK
1984	15	0	9	6	40%	27%
1983	24	7	6	11	65%	41%
1982	19	2	1	16	94%	83%
1981	16	2	3	11	79%	64%
1980	12	2	1	9	90%	70%
1979	21	8	4	9	69%	61%
1978	21	7	6	8	57%	57%
1977	35	20	11	4	27%	27%
TOTAL	163	48	41	74	64%	52%

* Percentages based only on vessels for which registry was available. Some vessels for which registry was not available may also have been ice strengthened.

Source : Lloyd's Registry Records

frozen together, if at all. Types of new ice are defined in the literature as follows:

"Frazil Ice":	Fine spicules or plates of ice suspended in water.
"Grease Ice":	A later stage of freezing than frazil ice when the crystals have coagulated to form a soupy layer on the surface. Grease ice reflects little light, giving the sea a matte appearance.
"Slush":	Snow which is saturated and mixed with water on land or ice surfaces, or as a viscous floating mass in water after a heavy snowfall.
"Shuga":	An accumulation of spongy white ice lumps, a few centimeters across; formed from grease ice or slush and sometimes from anchor ice rising to the surface.
"Nilas":	A thin elastic crust of ice, easily bending on waves and swell and, under pressure, thrusting in a pattern of interlocking "fingers" (finger rafting). Has a matte surface and is up to 10 millimeters in thickness.
"Ice Rind":	A brittle, shiny crust of ice formed on a quiet surface by direct freezing or from grease ice, usually in water of low salinity. Thickness to about 5 centimeters. Easily broken by wind or swell commonly breaking into rectangular pieces.
"Cake Ice"	Accumulations of relatively flat pieces of ice less than 20 metres across.
Brash Ice"	Accumulations of floating ice made up of fragments not more than 2 metres across - the wreckage of other forms of ice.

a) Prior to Diversion

The occurrence of new ice within the harbour has been a particularly difficult event to predict as it depends upon general climatic conditions, as well as upstream ice formations in the Churchill River and snowfall within the district. Further, once ice has started to form or collect, its continued existence within the harbour depends upon

climatic conditions, tidal influences and to a lesser extent wind direction.

The variations of early ice conditions have been observed throughout the 55 years of Port operations and are exemplified by the following reports:

- in 1972, Harbour tugs were frozen in slush ice as early as October 13th;
- in 1980, the M.V. "Arctic" left the Port on November 12th, when there was no ice within the Harbour.

This last event does not necessarily suggest that there had been no ice within the harbour previously; it could have been removed by the tidal currents with favourable wind conditions.

Weather conditions upstream of the Port have had a significant effect on the eventual presence of ice within the harbour. A heavy snowfall as far as a hundred and fifty kilometres upstream could cause large amounts of slush ice to flow into the harbour for days afterwards, adding to the other new ice already formed. This river ice load was often increased by the formation of frazil and grease ice as the flow passed through the rapids, south of the harbour.

Prior to Manitoba Hydro's diversion of the Churchill River in 1980, flow rates in the lower part of the river in October were in the order of 820 cubic metres per second (29,000 cfs). This high flow rate had a significant influence on harbour currents and caused large concentrations of frazil ice and ice cakes to flow past the Ports Canada wharf during ebb tides. Harbour bottom contours directed this flow along the face of the wharf, jamming ice between the wharf face and the berthed vessel, causing considerable difficulties.

Slush ice, combined with frazil and grease ice formed in the

river, also caused great difficulty to late season shipping. The operation of turning a vessel became difficult when there was a large quantity of ice in the harbour. However, early in the fall, ice does not occupy the entire area of the harbour so there is space for the ice to be pushed into, as the vessel turns. Later in the fall, when ice occupies most of the harbour areas, considerable horsepower is required to turn a vessel.

b) Post Diversion

Since the 1980 diversion of the Churchill River, the significance of each of these factors on harbour ice formation has changed, resulting in a later and generally less severe formation and accumulation of slush ice. Flow rates have been significantly reduced to the order of 130 cubic metres per second (4,600 cfs) in October. This has had significant direct and indirect influences on harbour conditions, and particularly on ice conditions. Unfortunately, no detailed records have been maintained to indicate the change of ice conditions since diversion. Only general observations of changed conditions are available.

In general, Ports Canada staff report that, since diversion, end of season harbour ice problems have been substantially reduced: with the reduced flow, most ice which forms from upstream snowstorms becomes trapped at the rapids just south of the harbour and, further, the reduced flow results in less frazil and grease ice forming at the rapids and eventually flowing into the harbour. Since diversion, therefore, with the reported reduction in river ice and the reduction in the formation of early new ice within the harbour, the potential navigation season has already been somewhat extended.

Wind direction and tidal flushing will continue to have a considerable effect on ice conditions within the harbour. A south wind, combined with an ebb tide, has often completely freed the harbour of

floating ice. The incidence of a south wind in October and November, unfortunately, is rather low. However, it is not unusual for an ebb tide, acting without the influence of a south wind, to clear the harbour of new ice at least partially. A north east wind, on the other hand, may move pack ice against the shore, thereby preventing dispersion of the harbour ice on the ebb tide currents.

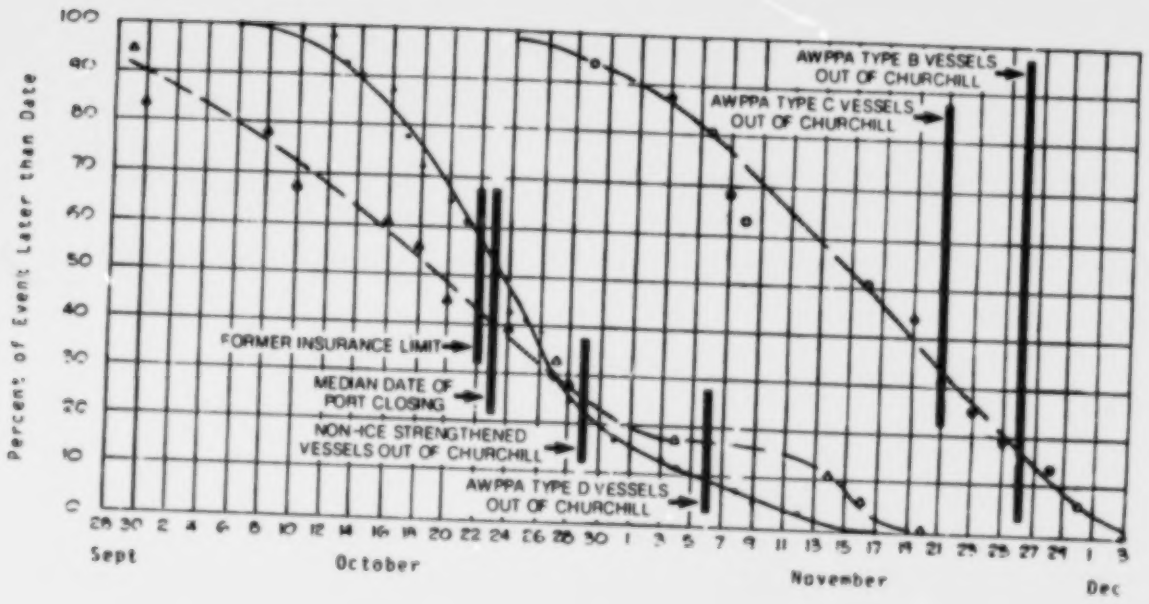
All of these substantially changed conditions, with little documented evidence of effected changes, make it extremely difficult to quantify accurately the net influence on late season ice conditions within the harbour. This suggests that an ongoing "new ice" monitoring program should be established immediately and given high priority. Such a program should record not only ice type, cover, thickness, etc., related to each tidal sequence, but also should be subjective in observing conditions of ice as they would affect vessel movements and Port operations. As suggested by the study team, Ports Canada staff commenced taking daily photographs and related observations of harbour ice conditions during October, 1985 and it is recommended that this be continued in future years.

Exhibit 3.5 presents a statistical analysis of harbour closing dates and occurrences of first ice and solid ice cover within the harbour, based on a variety of sources including the Port of Churchill and National Harbours Board annual reports. The analysis reveals the following relationship between significant dates and average ice conditions:

		% of Years in which Condition Occurs by the Date shown		
Date	Event	Open Water	Pack Ice	Complete Freeze Over in Harbour
Oct. 22	Former Insurance Limit	58%	41%	1%
Oct. 23	Median Date of Port Closing	53%	45%	2%

exhibit 3.5

CHURCHILL SEASON EXTENSION - ICE CONDITIONS



Harbour Closure

Complete Freeze Over, Harbour

First Permanent Ice

SOURCE: STEVENSON HLUCHAN ASSOCIATES LIMITED

Oct. 29	Non-Ice Reinforced Vessels out of Churchill	25%	69%	6%
Nov. 6	AWPPA Type D Vessels out of Churchill approaches	9%	71%	20%
Nov. 15	Proposed New Season Closing Date (as presented in Chapters 7 and 8	1%	52%	47%
Nov. 21	AWPPA Type C Vessels out of Churchill	0%	34%	66%
Nov. 26	AWPPA Type B Vessels out of Churchill	0%	18%	82%

The above data indicates that, by the latest likely departure date from Churchill as allowed by AWPPA for non-ice reinforced vessels (October 29), there would still be open water or pack ice experienced (i.e., the harbour would not be completely frozen over) in about 94 percent of years; this would drop to 80 percent for the last vessel Type D date (November 6), to about 53 percent by November 15, to about 34 percent by the last date for Type C vessels, and to about 18 percent by the last date for Type B vessels. Since about 64 percent of the grain vessels calling at Churchill (for which the registry is available) are ice-strengthened (Exhibit 3.4), a further season extension would appear to be feasible to November 6 for Type D vessels or better, to November 21 for Type C vessels or better and to November 26 for Type B vessels or better, based on AWPPA regulations and provided that appropriate tug and icebreaker arrangements can be made as discussed in the remainder of Chapter 3 and in Chapter 4.

It should be noted that the above data reflect information for years both before and after diversion of the Churchill River in 1980. They may therefore reflect, on average, more severe harbour icing conditions than have existed since the diversion and should be interpreted in that light.

3.2.6 Other Constraints

Extending the season into colder weather will have effects on the operation of the elevator as well as the Port.

Final freeze-up in Churchill harbour occurs on average about November 16th. Some time around this period ice may start to build up on the wharf itself due to tidal action and may cause difficulties to shipping. According to some references,[1], [2] a thin layer of ice may sometimes form on the vertical dock face with each tidal cycle. This layer could gradually build up and form an ice "bustle". Under such conditions vessels calling late in the season would have to berth a distance corresponding to the thickness of the bustle away from the wharf. If this were to happen, loading spouts on the wharf might not be able to distribute grain as effectively into the holds of a vessel being loaded. The spouts extend some 10-11 metres beyond the edge of the wharf, however, (depending on the tide level) which provides considerable capability to deal with ice gaps beyond the edge of the wharf. A discussion with a senior official of Ports Canada at the Port revealed that, in his experience over 30 years at the Port, the thickness of ice buildup on the wharf face remains under about one foot in the period to early December. It would therefore not be a problem in the season extension period (e.g. to December 6) under study.

It was reported to the study team by staff of the Port and the elevator that an extended season might require extra stevedores to handle loading pipes because less work is accomplished per man as the weather

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1. Ice Action on Wharf at Strachcona Sound, R. Frederking and N.K. Sinha, National Research Council of Canada, POAC 77 Volume 1

2. Ice Control for Arctic Ports and Harbours, Volume 1, Acres Consulting Services Limited, January 1983.

becomes colder. They did not see this as a significant factor for the first five or six weeks following the end of the normal season, however, and no additional cost was seen to be involved for a season extending into early December. They pointed out that stevedores work under equally cold conditions in other Eastern Canadian grain ports late in the season.

As treated elsewhere (sub-sections 4.6.2. and 7.1.2.) the three existing pairs of land based ranges have been found adequate for pilotage within the harbour by vessels using the harbour after the floating navigation aids become unreliable owing to movement by ice. After discussions with staff of the Canadian Coast Guard and of the Port it was concluded that the existing land based ranges would be adequate for use during an extended season (e.g. for icebreaking operations in the harbour). No costs were added, therefore, for additional navaids in the harbour but, as noted in sub-section 7.1.2., this situation would require monitoring and additional expenditures might be found necessary based on operating experience in an extended season.

3.2.7 Harbour Ice Development

Ice formation at Churchill is dependent on many variables, including precipitation, cloud cover, summer and fall heat gain, temperatures, humidity, river flows, river mixing, wind speeds, tidal action, salinity, tributary flows, ground water retention and others. Ice growth after initial formulation is dependent on air temperature, cloud cover, water temperature, river mixing, snow cover, wind speeds, sun angle, salinity, ice thickness and other factors.

As there are high tidal flows in the harbour most of the ice continues to move with the tide until at some instant it freezes over and remains relatively fixed in the horizontal plane. This is a very random event, as noted in Exhibit 3.5, and is probably closely related to the tides (particularly the timing of slack tide), air and water temperatures, snow fall, winds, snow cover, cloud cover and river flow.

We have not attempted to develop or redevelop a model or formula to predict ice conditions within the harbour for a particular year. We have however, developed a technique that statistically estimates ice conditions that may be expected, based solely on previous records.

Using the technique of hindcasting from known values, ice thicknesses and ice growth have been calculated and are presented in Exhibit 3.6. Generally, ice measurements on the river were recorded starting early December, after the ice was safe enough for vehicles. These values were related to the accumulated degree days for each date by using Zubov's empirical equation for sea ice growth.[3] The calculated values were corrected to the measured values for each year, then "hindcast" to establish earlier ice thicknesses. The thicknesses were also forecast for later dates and compared to actual ice measurements. The data were analyzed statistically and are presented in Exhibit 3.6. It is noted the calculated values and the actual ice thickness observations for dates late in the season correspond very closely.

However, the ice thickness, or ice growth, does not take into account and seems to be unrelated to the actual date of complete freeze-over, or the date the ice stops moving. These values are noted in Exhibit 3.5.

Freeze-over and stopping of ice movement can occur any time from late October to early December, with the average date being November 16th. In four out of five years, the freeze-over and stopping of ice movement is likely to occur after November 6th. Ice thicknesses upon freeze-up seem to be independent of the actual freeze-over date, although they probably are not completely so. In any case, they were treated independently to analyze the values statistically.

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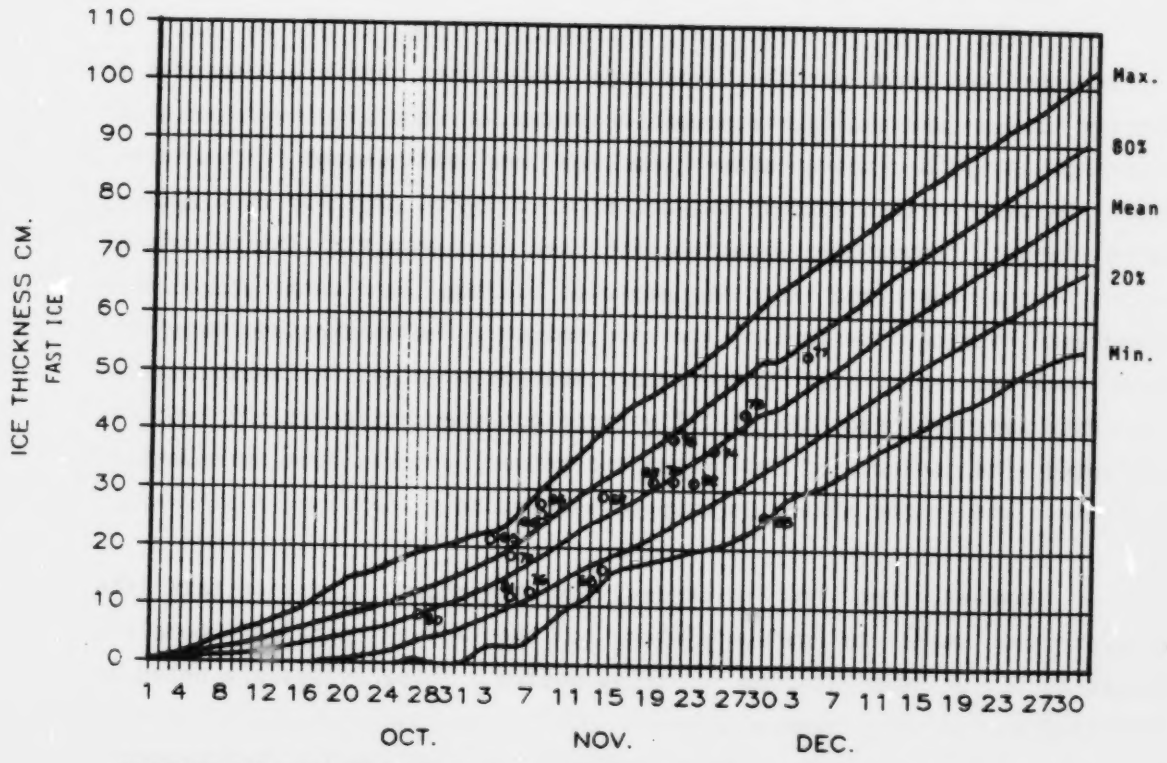
3. Sea Ice Growth in Arctic Canada, D.M. Leahey, Dept. of Transport Met. Branch, Feb. 6, 1967. UDC 5S1.311.18.

exhibit 3.6

HINDCAST ICE THICKNESS



HINDCAST ICE THICKNESS AND FREEZE-OVER DATA FOR THE YEARS 1969 to NOVEMBER, 1985
o81 indicates recorded date of freeze-over

SOURCE : STEVENSON HLUCHAN ASSOCIATES LIMITED

Upon freeze-over, ice thicknesses range from 7 to 54 centimeters, with an average of 28 centimeters and the likelihood that four out of five years (80%) the thickness will be less than 38 centimeters and greater than 17 centimeters. Multiplying these "independent" events together, the probability of having ice of a particular thickness frozen solid after a particular date can be calculated. For example, the likelihood of having a solid field of ice, at the Port of Churchill within the harbour, greater than 15 cm by November 6th will be the probability of having ice of any thickness freeze over as obtained from Exhibit 3.5 multiplied by the probability of having ice of a particular thickness on the specified date, as obtained from Figure 3.6. From Exhibit 3.5, on November 6, there is an 80% probability that freeze-over will occur after that date, therefore there is a probability of 100-80 = 20% that freeze-over will occur by that date. From Exhibit 3.6 there is a 50% chance that there will be ice less than 15 cm thick on that date so there is a probability of 100-50 = 50% that there will be ice greater than 15 cm thick. Multiplying these two probabilities together reveals that there is a probability of 0.20 x 0.50 = 0.1 or 10% that the stated condition will be exceeded (e.g. that it is likely to occur about one year in ten).

These graphs are a useful tool to predict, statistically, the long term late season operating environment in the harbour at Churchill. Given the design capabilities and design operating environment of the new harbour tug it is possible to estimate its effective operating season. The following table presents the estimated probability of the tug <u>not</u> being able to operate as designed on or after a particular date if fast ice is allowed to form in the harbour. The criterion being used is that the tug is designed to operate in up to 15 cm of new fast ice and up to 30 cm of slush ice.

Date	Probability of Design Conditions Being Exceeded
Oct.31	2% or 1 in 50 years
Nov. 6	10% or 1 in 10 years
Nov.15	47% or 1 in 2 years

If the new tug were designed to operate in up to 30 cm of new fast ice the estimated probability of design conditions being exceeded as of November 15 would be reduced to about 15%, or about one year in seven.

It is important to realize, however, that the above probabilities are based on a theoretical situation in which the ice would be left undisturbed to freeze over and become fast ice. In practice, the harbour tug in an extended season (as is common practice in many northern harbours) will operate continually in the harbour to break new ice as it forms and prevent thick, fast ice from forming until the closing date. If the closing date is November 15 as proposed by this study (see Chapters 7 and 8) the tug, with its design capability of operating in up to 15 cm of fast ice and up to 30 cm of slush ice, would therefore be capable of keeping the harbour open in most years (e.g. about six years out of seven) by operating in this fashion.

3.3 PREVIOUS STUDIES

Since initial development of the Port in 1928 to 1933, Churchill has been the subject of numerous studies which have sought to improve harbour conditions and increase annual cargo movements of both grains and other commodities. During that period, the physical facilities of the Port were almost doubled by increasing the elevator storage capacity from 2.5 million to 5.0 million bushels in 1955, and by increasing the grain dock length from 1,550 feet to 2,750 feet in 1963.

The most intensive period of studies commenced in 1966, when the National Research Council was commissioned to investigate the "Feasibility of Extending Navigation Season at Churchill Harbour". The study, which was carried out by T.M. Dick and published in December, 1966, also considered the likely influence of Manitoba Hydro's proposed Churchill River diversion for their Nelson River power development project. The report concluded that:

"It should be feasible to extend the shipping season by an average of 14 days, dependent upon certain changes in the conditions of operations: (i.e.) improvement of aids to navigation, provision of icebreaker escort service, more frequent aerial ice reconnaissance, and employment of ice-strengthened vessels."

In considering the diversion project, the report concluded that:

- Ice production commences in the river earlier than in the sea, and it is this ice that results in closure of the harbour.
- Snow or blizzard conditions have a marked effect on the river, and bring about heavy slush ice conditions.
- Diversion of the river would greatly reduce the freshwater flow which would encourage the formation of a solid ice cover, thus inhibiting frazil ice production.
- The diversion would cause river ice to appear a few days earlier, but the volume of ice should be substantially reduced.

The report also examined possible means of mitigating ice conditions within the harbour, and concluded that:

- Direct physical exclusion of the ice by means of dredging, dikes or diversion so that more of the ice passes through the harbour seemed the most useful approach.

Later in 1974, the National Research Council (NRC) was authorized to carry out a saltwater tidal model testing of the lower estuary of the Churchill River. The purpose of the model was to investigate means of mitigating the effects of ice on shipping operations. The NRC study[4] investigated the conditions both with and without the diversion and evaluated the effectiveness of various deflecting piers and estuary dams. The study concluded that:

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4. Unpublished NRC Investigations, 1984.

- The river discharge reduction will result in a considerable reduction in river ice production and the harbour should experience less trouble with slush ice in the future;

- A deflecting berm, projecting from the south end of the wharf, was found to be useful in giving protection from ice and currents at the berths. However, the study also recommended to "wait and see the effect on the ice production and the harbour conditions before implementing any scheme to deflect the ice away from the dock".

3.4 OPERATING SCENARIOS

In order to appreciate the sequence of ice formations and movements within Churchill harbour, and their influence on shipping operations, a weekly scenario has been developed, commencing with the third week in October until the end of November when freeze-over has generally occurred.

3.4.1 Week 1 - Oct. 15th to 22nd

Ice is just starting to form in measurable quantities from shore; occasional flows of river ice or slush ice may move into the harbour area but, unless there are unfavorable winds, they are usually carried out into the bay with the next tide. The bay remains open and very little river ice that has moved into the bay returns on the flood tide. There is little hindrance to navigation and no additional assistance would be required. On occasion, slush ice may slow turning operations, however, this situation should pass quickly. It is improbable that any vessel would get stuck using the present equipment. Channel buoys may periodically need to be repositioned and replaced as ice may carry them out to sea.

In the past twenty years there have been three occasions of significant navigation problems during this week and two of the three events cleared themselves after a period of time. They originated from

very heavy accumulations of slush ice, sometimes over 1.0 m thick, coming down into the harbour from the river. Since the diversion, with very little slush ice entering the harbour from the river, the likelihood of heavy accumulation is rare. In fact since the diversion there has been no reported hindrance to Port operation caused by slush ice.

3.4.2 Week 2 - October 23rd to October 31st:

Ice is forming and growing from shore. Heavy flows of harbour ice and some slush ice may occasionally collect in the harbour, but they are still generally moving out to sea with the tide. As indicated in Exhibit 3.5, the probability of complete freeze over is in the order of once in 16 years. In years previous to the diversion the period from mid-October to mid-November would be greatly affected by the slush ice problem as previously discussed. This, however, apparently has not been a major problem since the diversion. Most of the time the wharf area is clear of ice. Vessels would be advised, however, to take care with their upstream lines to make sure that a wedge of slush or river ice does not accumulate between the vessel and the wharf and push the vessel off. Maneuvering within the harbour, including turning the vessels, could be accomplished with the present equipment available; however, on occasion one could expect to get stuck in the ice for up to several hours, depending on the tides, and even longer with very unfavorable winds. A more powerful tug would tend to alleviate this situation and reduce the chances of lost time. In a normal year, the aids to navigation within the harbour would be removed during this week (or shifted by the ice) so extra caution for vessels entering and leaving the harbour would be required.

Vessels could turn at the wharf as in normal practice if there were no ice present; however, if some did accumulate, either the tug would have to make some effort to clear the ice, if conditions permitted, or the vessel would have to wait until the tidal flow had caused conditions to change.

3.4.3 Week 3 - November 1st to 7th:

Ice growth within the harbour and up the river is quite significant by this time. Normal growths up to 25 centimeters in thickness could be expected and it is now likely that the ice could cover the entire harbour for periods of time at least, and the probability is approximately 20% that the ice cover will freeze fast by the end of the week. Heavy local snowfalls would also add to accumulations of ice in the harbour, as is reported for this year (1985).

Significant quantities of ice could be expected and will delay shipping operations. The shore ice is increasing in width and, although it poses no hindrance to navigation, it may cause additional accumulation of floating ice. Ice within the bay is also starting to accumulate, particularly along the shore. Vessels could in most cases carry on with very few problems using regular operating equipment.

In years prior to the diversion, slush ice would typically cause vessels, at least once during the week, to be stuck or delayed for at least one tide. Additional tug power would be required to alleviate the problems, to push floating ice and to break and clear some of the growing accumulation that may start to become fixed to the shore ice. The harbour will still clear itself with tides and favourable wind conditions; however, ice in the bay may re-enter or block the entrance under unfavorable winds. A harbour tug should have enough horsepower to turn vessels in light accumulations of floating ice, or to clear ice in the wharf vicinity when required for loading and shipping operations. It may be desirable to maintain the turning area clear of ice by continually breaking up and clearing accumulations with tidal assistance.

3.4.4 Week 4 - November 8th to November 15th:

Ice is very prevalent in the harbour; shore ice has extended across the harbour and may reach substantial thickness. By the end of the

week there is a 50% probability that the harbour will be frozen over; if not there would be large ice floes that may clear or partially clear with the tides. Prior to the diversion, slush ice may still have been moving into the harbour and may have accumulated there, such that operations would be brought to a temporary halt. Access to the bay may be limited due to ice accumulation there; however, the harbour tends to flush itself periodically of floating ice on the ebb tides. Berthing and turning maneuvers would require a heavy tug of at least 2,000 HP, for pushing or clearing floating ice from the dock face as well as turning the vessel. Ice breaking capabilities would also be required to clear fast ice and to open channels and provide maneuvering space as required. There is a 47 percent probability that the harbour may become permanently frozen unless the harbour tug operates continually as required to prevent fast ice from forming, or conventional icebreaker assistance is obtained. A substantial portion of the bay at Churchill will be ice covered or be congested with floating pack or raft ice. Any vessels using the facility at this time would be ice strengthened to at least AWPPA Type D classification. The winter berth would generally be frozen over by the end of this week, such that the harbour tug would have to keep breaking the ice in the winter berth as well as in the harbour in order to enable it to move into the winter berth at the end of the week (or a few days earlier if required in years of early, heavy ice formation).

3.4.5 Week 5 - November 16th to November 22nd:

In four out of five years the harbour would be completely frozen over by the end of the week with up to 50 centimeters of ice (e.g. as in this year 1985). Otherwise, ice will generally be covering the harbour, with some open patches or reaches present. Portions of the ice may move in and out with the tides; however, large accumulations of shore ice in Hudson Bay will prevent much movement. Most of what goes out with one tide will return on the next. Within the navigation channel, the ice may approach 50 centimeters in thickness in some areas, and may start accumulating on the dock face as an ice bustle. This might interfere with

vessel loading, particularly if the vessel were very large although, as pointed out earlier in sub-section 3.2.7, this is not expected to be a problem for season extension into late November or early December.

Harbour operators would have to maintain a clear channel, to clear the turning area so the vessel may swing, and to clear ice from the dock face. Slush ice and river ice would not be a problem as the river would be frozen by this time. The icebreaker would also be required to clear a channel to the open bay upon arrival and departure of the cargo vessels. In some years, a portion of the main channel may be naturally cleared of ice by the tides, allowing almost normal shipping operations; however, an icebreaker or a large icebreaking tug would have to be available at all times. AWPPA Class C vessels would use the facilities under these conditions.

3.4.6 Week 6 - November 23rd to November 30th:

The end of the week would be considered for all practical reasons the end of the possible season extension without resorting to full icebreaking and Arctic travel conditions. The harbour would be completely frozen over with ice accumulation up to 62 centimeters, the mean being 43 centimeters. There is a very remote chance, 1 in 16, that a portion of the channel may be clear after this week; however, it still would require massive effort to complete the normal berthing, turning, loading and departing operation. Operations during the week would require constant icebreaker assistance to clear the basin, dock face and turning area. The vessel would have to be suitably reinforced to AWPPA Class C, or better. A good portion of the bay at the harbour entrance would be frozen solid and would require at least a Class 2 icebreaker.

3.5 ICE MANAGEMENT

3.5.1 Alternative Techniques

Ice management is the utilizing of special ice control techniques

separately or combined with a range of harbour design features which will mitigate the effects of ice conditions on port operations. These techniques and features are represented by four broad categories:

(i) ice suppression, which restricts the formation of ice;

(ii) ice breaking, which includes the breaking, cutting or destruction of ice;

(iii) ice removal, which involves the physical displacement of ice, and

(iv) ice diversion, which is the deflection or arresting of ice to prevent intrusion into areas where it is unwanted.

The recognized techniques[5] for each of these categories include:

(i) ice suppression
- . thermal discharge
- . bubblers
- . wave-making devices
- . ice dusting
- . insulating
- . floats and pontoons
- . enclosures

(ii) ice breaking
- . conventional icebreakers
- . air cushion vehicles (ACU)
- . archimedean screw tractor
- . mechanical ice cutting (MIC)
- . explosives
- . thermal ice cutting
- . water jet ice cutting
- . laser ice cutting
- . chemical ice cutting

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5. "Ice Control for Arctic Ports and Harbours", Acres Consulting Services Limited, Jan. 1983. (AST)

(iii) ice removal
- lifting
- towing and parking
- conveyors
- slurry pipelines

(iv) ice diversion
- booms
- structures
- flow developers

The conditions found in Churchill harbour present challenges to ice management that are not usually found in most Arctic or sub-Arctic ports. Churchill's high tides, river current, frequent unfavorable winds, and (before the diversion) early ice from the Churchill river all may contribute to impeding safe vessel operations within the Port during the potential extended season period.

However, the major ice problems at Churchill which would inhibit extended season operations in the fall appear to have been substantially mitigated since diversion by the reduced river flow and, consequently, the accompanying reduction in early loose ice (slush, frazil, grease, etc.). This reduction has therefore also mitigated difficulties in turning vessels at berth and in holding vessels against the berth.

3.5.2 Evaluation

Based on the experience of the study team and on past studies, particularly those done by the National Research Council, the only techniques of ice management which would be effective would be to conduct icebreaking operations in the harbour or construct a diversion structure which would reduce the amount of ice intruding into the berth areas. The cost of such a structure would be significant and would be justified only after demonstration that present post diversion conditions are severely impeding operations. In addition, as discussed earlier the new tug will be important as a means of preventing fast ice from forming next to the wharf and in the exit channel. Ice suppression techniques would be

largely ineffective because of the river and tidal currents and ice removal would be similarly affected and very costly. Exhibit 3.7 summarizes the evaluation of ice management techniques for Churchill harbour.

As pointed out earlier in this chapter (subsection 3.2.7) it would be desirable to have the new tug further strengthened so that it could operate in fast ice of up to 30 cm. A broad estimate of the cost to achieve this further strengthening, however, received verbally from the tug designers, is about $2 million. A more cost-effective solution would therefore be to proceed with the proposed extension to November 15 with the new tug as currently designed, calling in conventional icebreaker support to break ice in the harbour in the relatively small number of years when the tug may require assistance. Because of the anticipated low frequency of such occurrences, the relatively thin ice occurring up to November 15, and the fact that assistance would be generally required only for vessels leaving the harbour during the last week of the season, this occasional and restricted use of a conventional icebreaker in the harbour would not require dredging of the turning area. The additional cost for such dredging could be required only for season extension beyond November 15, when more extensive harbour icebreaking would be required on a routine basis by conventional icebreakers over the entire turning area.

By operating the new tug continually at critical times in years of heavy ice to keep fast ice from forming in the harbour, as pointed out in sub-section 3.2.7 and the previous paragraph, the harbour can be kept open in most years up to November 15 using the new tug with its design capability of operating in up to 15 cm of fast ice and up to 30 cm of slush ice. In the occasional year when this may not be possible, conventional icebreaker support would be called upon in the harbour. For season extension beyond November 15, it is concluded that of all of the ice management techniques available, the use of conventional icebreakers is the most practical means of dealing with fixed ice conditions.

EXHIBIT 3.7

EVALUATION OF ICE MANAGEMENT TECHNIQUES
FOR CHURCHILL HARBOUR

	DESCRIPTION	CONSTRUCTION	CAPTIAL COST	EFFECTIVENESS	PROBLEMS AND ENVIRONMENTAL CONCERNS
1.0 BUBBLER					
1.1 Continuous	Surpresses ice formation and growth by circulating warmer water, rising with the bubble pluse, from the lower levels of the water body. Requires a temperature gradient from water to bed levels to be most effective.	Systee consists of a compressor(s) pumping air through a pipeline located near the bed of a water body. Pipeline is constructed with regularly spaced minute orifices along its length, allowing the air to escape and form a pluse or column to the surface.	Low, Dependent on Size of systee installed.	Not effective in flowing ice. May be effective in suppressing ice growth once the river ice has stopped moving. Dependent on water temperature, mixing, salinity, velocity, depth and thermal reserve. NRC study (1966) indicates near freezing temperatures for water under the ice, not enough to efficiently clear large quantities of ice.	No environmental concerns. Physical problems with placing and protecting subserged pipelines on river bed under deep draft vessels. Pipelines are raised slightly off the bottom to prevent clogging of the orifices. Amount of power required for system is proportional to water temperature below freezing.
1.2 Air Cannon Mixer (Burpers)	Suppresses ice growth similar to the continuous bubbler and also by agitating the water at the surface.	Compressed air is released in regular bursts at the bottom of a verticle tube near the bed of the waterbody. This induces large water flows up the tube to the surface. Usually located at the wharf's edge.	Low - similar to the continuous bubbler systee	Similar to the continuous bubbler	Similar to the continuous bubbler. These units can be easily installed and removed, they may be connected by flexible hose to the compressors and installed by lowering the tube through a hole in the ice.
2.0 ICE BREAKING					
2.1 Conventional Ice Breaker	Artic Class 2	Specialized	Very High	Very Good during the early winter. Breaking up ice, clearing intial channel allowing it to flow out of the harbour on the tides. Not effective and will cause a build up of ice after several passes if ice cannot escape into the bay. Operates effectively in 60 cm of ice.	Little environmental concern. May have problem operating near the wharf face and would require a larger turning basin to work effectively within the harbour. CCG ice breakers do not normally operate as tugs and are reluctant to do so.
2.2 New Churchill Tug	Class C equivalent vessel	Steel hull (reinforced) 2600 hp.	$2.7 million	Can operate through fast ice up to 15 cm and operate in slush ice up to 30 cm. May be able to maintain loose ice within the harbour by continous operation at critical times, with tidal flows to clear broken ice.	No environmental problems. Tug can only operate in fast ice up to 15 cm. Winter berthing problems if ice thickness exceeds these values. Tug may not be able to enter the basin.
2.3 Ice Breaking Harbour Tug	Artic Class 1, 1A	Specialized, Ice Breaking Bow	High: about 100% greater than conventional tug.	Good, effective capacity up to 30 cm of fast ice, other characteristics similar to the Conventional ice breaker.	No environmental concern. During most of the year it would operate as a normal harbour tug. Winter berthing may present problems in late season operation.
2.4 Air Cushion Icebreaking Bow/Tug Combination	Conventional tug fitted with ACIB. Breaks ice by air pressure depressing the water under the ice, causing the ice sheet to break in bending.	Normal Harbour Tug fitted with ACIB as required to break and clear ice. ACIB is fitted with normal air cushion vehicle equipment, compressor, skirting, etc.	High	Good, although not fully developed and tested. Would significantly improve ice capacity of normal harbour tug. ACIB may be fitted to several different vessels.	No environmental concern. ACIB can be installed or mounted on conventional tug or vessels. Additional time required to install units, crane required as it would be stored on the wharf. Unit would have to be removed to allow tug to perform normal berthing manouvers.
2.5 Explosives	Explosive charges placed under the ice. Traditionally used to break ice jams.	Augering equipment to place explosives	Low	Very effective in specific situations. May be applicable to clearing the channel at the harbour entrance, to allow passage of ice, also to clear channel into the winter berth.	Some environmental impact, may damage wildlife. Danger in handling explosives and in placing charges, safety concern with men on the ice in mid November.

EXHIBIT 3.7

EVALUATION OF ICE MANAGEMENT TECHNIQUES
FOR CHURCHILL HARBOUR

	DESCRIPTION	CONSTRUCTION	CAPTIAL COST	EFFECTIVENESS	PROBLEMS AND ENVIRONMENTAL CONCERNS
2.6 Self Propelled Mechanical Ice Cutter	Generally for small scale operations. Still under research and development, no system in use at present time.			Still being researched and developed, maybe effective in control situations but not proven in the field	At Churchill season extension relates to ice problems during the month of November. The ice at that time is very unstable and is generally not safe enough for traversing until early December. So any control measures that require men and equipment to be on the ice during the month without provisions for ice break up would be unsafe, and not acceptable. Archimedian Ice Screw may be an effective transporter.
2.7 Thermal Ice Cuttings	Same as 2.6			Same as 2.6	
2.8 High Pressure Water Jets	Same as 2.6			Same as 2.6	
2.9 Lasers	Same as 2.6				
2.10 Chemicals	Same as 2.6 and may also have serious environmental problems.			Same as 2.6	
				Same as 2.6	
3.0 ICE DIVERSION					
3.1 Booms	Retention device skimming the water surface trapping the moving ice. Ice retemetion on the upstream side of the boom, effectively stops ice from passing while allowing water flow to continue under.	Consists generally of a heavy cable supported by floats and secured at either end, Spanning across or partially across a flowing water body.	Boom itself is low in cost. Securing Structures may be moderate cost.	Very effective in controling ice from entering wharf area and turing basin if placed correctly. Booms have proven to be effective in many locations.	No environmental problems. Boom will probably be lost every spring breakup and have to be replaced. Substancial structures would be required to anchor either end of the boom. Because of the reverse directions of the flow pattern the boom may be lifted or otherwise displaced during these shifts.
3.2 Structures	Solid structures which form a barrier preventing ice moving into the navigation channel or harbour area from upstream. The barrier is completed in the permiable structure by ice bridging between the cells. Ice may be restrained by the structure or by an ice jam or dam that forms between individual structures.	Typically any solid marine structure such as timber crib, sheet pile cells or wall and wharf concrete caissons. The structures would be designed, positioned and orientated to effectively reduce ice intrusion and collection problems near the wharf face and in the turning basin.	High	Somewhat effective in alleviating ice problem at Churchill. Very effective in prevention upstream ice from passing in front of the wharf and in creating a new flow pattern that directs returning ice away from the wharf face. This type of structure was extensively studied by NRC in 1975. They concluded that conditions in the harbour would improve after the diversion and that only if conditions were such that additional protection is warranted should a solid diversion be examined. A permeable structure would retain most of the ice upstream. It also would allow flow across the wharf face to clear any transient ice that returns to the area on the flood tide. An ice boom could also be incorporated into the design.	Some environmental problems are that a solid structure changes flow patterns which may cause a new channel to be eroded and may also increase sedimentation within the harbour. A dead water pocket between the wharf and the barrier may be created the ice will tend to collect and not be flushed out by tidal flows. A permiable structure will not prevent ice from being flushed into the bay on the ebb tides. More effective in combination with other forms of ice control, ie. Icebreaker Tug.
3.3 Flow Deflectors	Ice control by inducing flow in the water body to carry or deflect ice from the structure.	Several methods including physical barriers changing or deflecting current, propellor mechanisms and air bubblers. Physical barriers are similar to Ice retaining structures, dredged channels and submerged bares.	Moderate to High for physical deflector. Low for other installations.	Physical deflector may be somewhat effective and would behave similarly to the ice barriers. Very strong tidal flows would render mechanical systems useless.	No environmental problems. Potentional scouring and sedimentation problems with deflector systems.

EXHIBIT 3.7

EVALUATION OF ICE MANAGEMENT TECHNIQUES
FOR CHURCHILL HARBOUR

	DESCRIPTION	CONSTRUCTION	CAPTIAL COST	EFFECTIVENESS	PROBLEMS AND ENVIRONMENTAL CONCERNS
4.0 ICE REMOVAL	These methods call for removal of ice by other than natural forces.			Due to the highly transient nature of the ice at Churchill it would be a never ending battle to remove the ice from the berths by any other than natural means. These methods would not be effective in areas other than in the winter berth area where a channel could be excavated if required.	
4.1 Towing or Pushing	Harbour Tug		High		
4.2 Conveyors and Slurry Pipelines	Shore or barge based equipment excavating and pumping ice to disposal site.		Moderate		
4.3 Removal by lifting	Shore based crane lifting ice from channel and berths		Moderate		

Cost Rating ($ Millions)

Under .5 = Low

.5 - 2 = Moderate

2 - 10 = High

Over 10 = Very High

IBI GROUP

The next most effective technique would be an ice diversion structure upstream of the berth areas, but the need for this appears to have been reduced or removed by the flow diversion of the Churchill River. The possibility of constructing an ice diversion structure should therefore be deferred until operating experience has been gained with an extended season; the study team considers it unlikely that investment in such a structure would be required or justified as a measure to help achieve season extension for extension dates within the AWPPA limits described earlier.

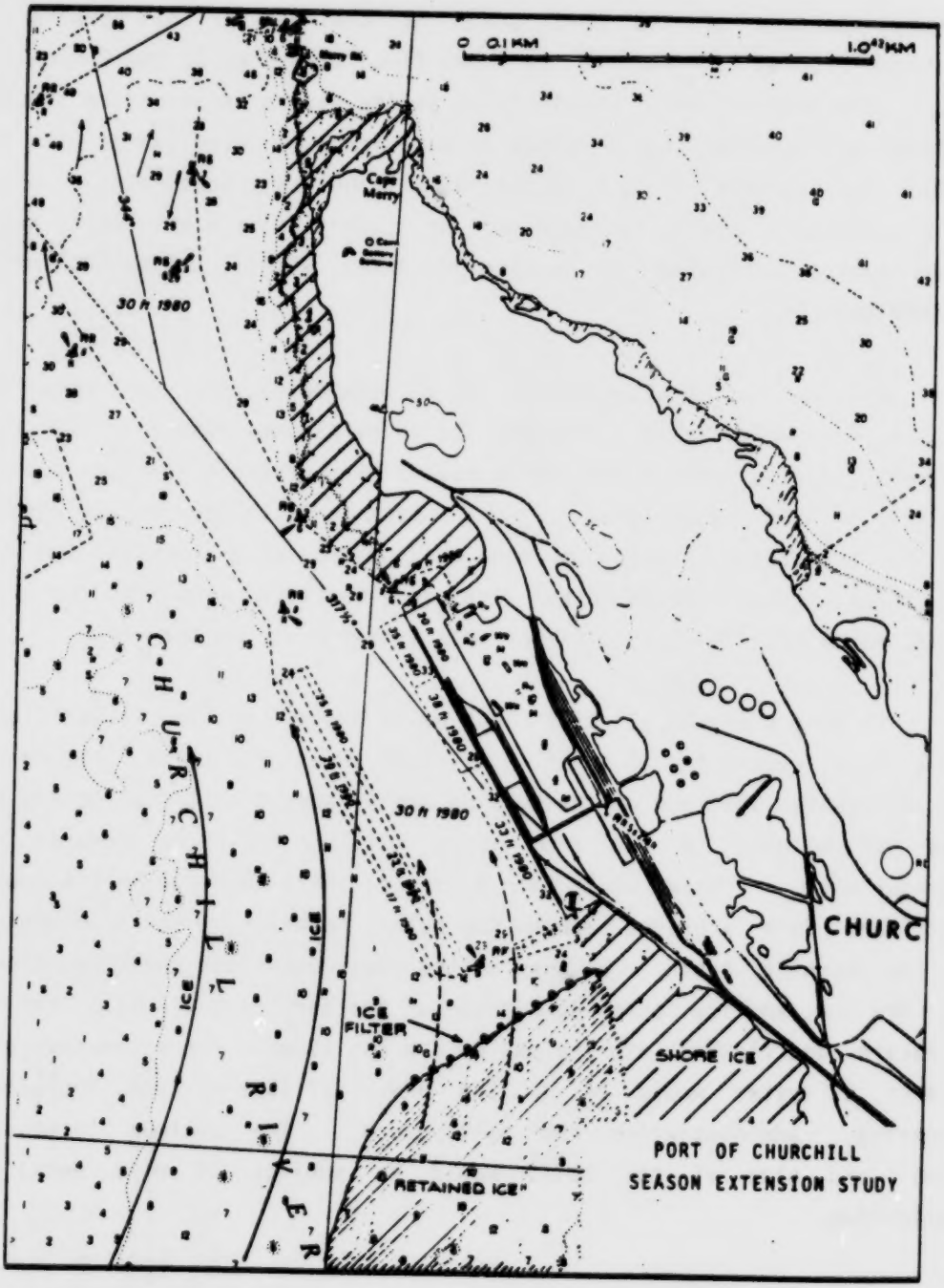
If such a structure were to be considered, the ideal solution would be one which allows broken ice to be cleared naturally from the berth area during ebb tides while restraining upstream ice from moving into the vacated berth area. An ice boom could be the most effective means of arresting this ice movement while maintaining the river and ebb tidal flows, which should clear ice from the berth area into the bay. However, annual maintenance costs for this system could be very high.

A more suitable solution might be to install an "Ice Filter" (see Exhibit 3.8), consisting of a series of steel sheet pile cells. The cells would be located upstream of the turning basin, spaced at approximately 30 metres and aligned to run from shore out into the river, towards the south-southwest. These would form a barrier where late season ice would collect and form a bridge between the cells, restricting ice from moving into the turning basin. Because of the continual river and tidal flows under the ice, any ice formed downstream of the barrier could be broken by icebreakers and flushed into the bay by the ebb tides. The estimated cost for such a system would be in the order of $3.2 million, including engineering, administration and contingency. The optimum location, spacing and size of the cells would be subject to more detailed investigation.

Regardless of when extended season operations are commenced, or what techniques of ice management are employed, it is imperative that the

exhibit 3.8

POSSIBLE ICE FILTER STRUCTURE



current monitoring of ice development and the assessment of operating conditions be continued, even after extended season operations have commenced. This is important to obtain a better understanding of those factors over a number of years. The additional cost will be negligible since these observations are taken by Port staff and the time required is small.

In order to accommodate icebreaking and vessel turning during a season extension later than November 15, the turning area opposite the berths would have to be widened from 300 metres to 365 metres, and dredged to a 9.2 metre depth below datum, as described more fully in Section 6.4, at an estimated cost of $3.1 million. This is approximately the same cost as that estimated for the ice filter. Neither investment is recommended since, as presented in Chapters 7 and 8, season extension is proposed only to November 15. If a longer season were contemplated, the dredging investment would be required, while the ice filter investment probably would not be justified, as noted earlier. This is because the use of conventional icebreaking in the harbour (enabled by the dredging) would probably remove the need for the ice filter, while the ice filter would probably not remove the need for the icebreaking.

It is anticipated that annual costs to maintain this dredged depth in the turning area would be minimal. Depths from the 1985 sounding survey, as compared to the soundings charted after the 1980 dredging program was completed adjacent to the areas where the additional dredging will be required, show that very little or no sedimentation has occurred and no redredging is required. Assuming that the proposed dredging program for season extension does not alter river flow patterns drastically, which it should not, minimal maintenance dredging will be required, involving only the occasional removal of high spots. This would be easily done, for minimal costs, using Port equipment and manpower.

3.6 SUMMARY: IN PORT SEASON EXTENSION CONSTRAINTS

The constraints to season extension in the fall as imposed by harbour conditions are summarized in Exhibit 3.9.

The factors which have hitherto forced early closing, the winter berthing requirements for the tug "Twolan" (October 18, 1985) and the vessel insurance limit (October 22), will both be removed in future years, by construction of the new tug for Churchill (with its lesser draft) and by the adoption of AWPPA dates on the new insurance limits during the fall of 1985 by London underwriters for vessels making voyages to Churchill.

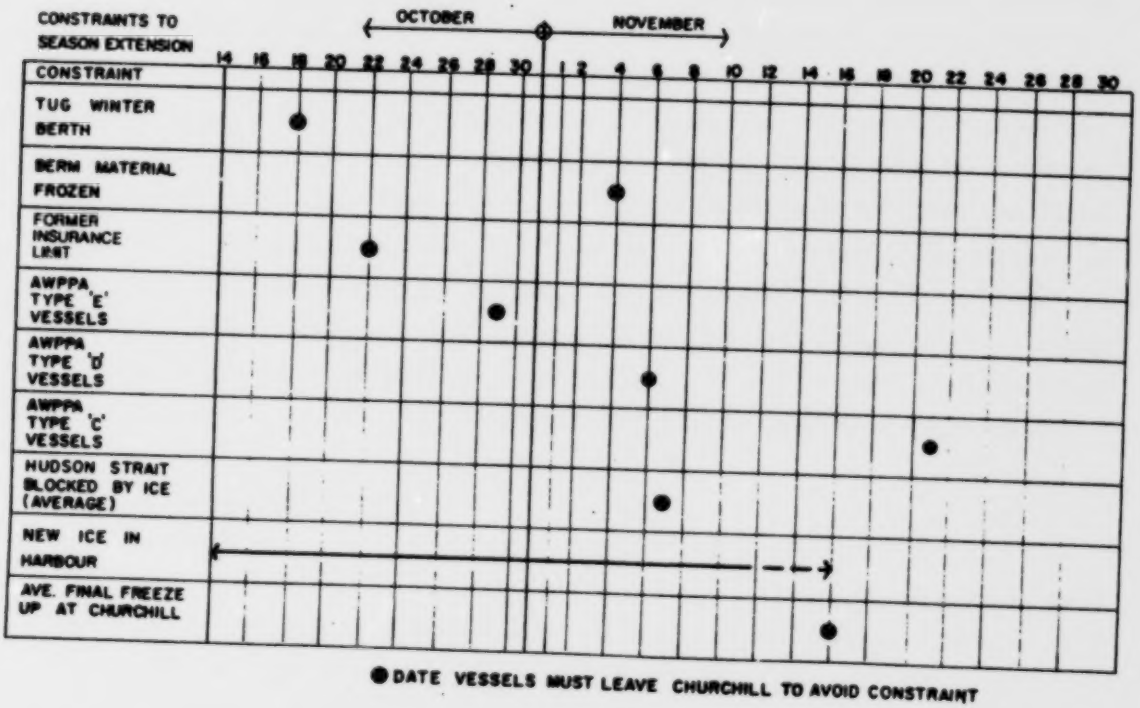
While the AWPPA regulations require all non-ice strengthened (Type E) vessels to leave Churchill by about October 29, this constraint could be relieved with icebreaker escort, as could the November 6 constraint due to AWPPA restrictions on Type D vessels which is related to the average date (November 7) when Hudson Strait becomes blocked by ice. Alternatively, as discussed in Chapter 8, the season could be extended for example to November 15, with the understanding that AWPPA limitations would apply: all Type E vessels would leave Churchill by October 29 and all Type D vessels by November 6, while Type C and higher ice classification vessels would operate up to the November 15 closing date.

The other early November constraint, freezing of the berm material used to isolate the winter berth from tidal action, can be overcome by covering the berm material to keep it dry, by heating, or by construction of a gate.

These factors, and the costs of relieving the constraints and allowing Port operations into successively later weeks during the fall, are taken into account in Chapters 5, 6 and 7, in assessing the costs of season extension.

exhibit 3.9

CONSTRAINTS TO SEASON EXTENSION


CONSTRAINTS TO SEASON EXTENSION
OCTOBER
NOVEMBER
14 16 18 20 22 24 26 28 30 1 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
CONSTRAINT
TUG WINTER BERTH
BERM MATERIAL FROZEN
FORMER INSURANCE LIMIT
AWPPA TYPE 'E' VESSELS
AWPPA TYPE 'D' VESSELS
AWPPA TYPE 'C' VESSELS
HUDSON STRAIT BLOCKED BY ICE (AVERAGE)
NEW ICE IN HARBOUR
AVE. FINAL FREEZE UP AT CHURCHILL
● DATE VESSELS MUST LEAVE CHURCHILL TO AVOID CONSTRAINT

SOURCE: STEVENSON HLUCHAN ASSOCIATES LIMITED

4. SEASON EXTENSION EN ROUTE

In this chapter, the climatic factors constraining the movement of grain and other vessels between the Port of Churchill and Cape Chidley at the beginning and end of the shipping season are reviewed. These factors include the ice conditions along the route, the constraints of the Arctic Waters Pollution Prevention Act (AWPPA), the availability of ice strengthened bulk carriers used in the grain trade which meet the AWPPA guidelines, the availability of icebreakers to escort the vessels in conditions of extensive ice coverage, and the availability of insurance at reasonable rates for vessels travelling to the Port of Churchill. Based on these factors, operational activities for extending the season in weekly increments at both the start and end of the season are developed.

4.1 EXISTING SEASON LIMITS

Navigation into the Port of Churchill is presently conducted from late July until late October. At the start of the season, the climatic limitations to the season stem from the ice conditions in the area south of Foxe Channel through which vessels must pass while travelling from Hudson Strait to Hudson Bay. These conditions are reflected in the limits placed on navigation at the start of the season by AWPPA, as illustrated in Exhibit 4.1 (and earlier in Exhibit 1.2). The unavailability (prior to the changed insurance arrangements described in sub-section 1.3.1) of insurance for many commercial vessels before the beginning of the "normal" season also delayed the start of the shipping season to the Port of Churchill. In the past, London underwriters had set July 23rd as the earliest date for vessels to pass Cape Chidley en route to Churchill. As noted in sub-section 1.3.1 the underwriters are now prepared to provide insurance on a case-by-case basis for vessels sailing outside of the season as previously defined and have agreed in future to link the insurance period to the season limits outlined in AWPPA regulations, as is

exhibit 4.1

AWPPA LIMITS ON NAVIGATION TO & FROM CHURCHILL

VESSEL CATEGORY	ZONE 14 (NE-HUDSON BAY)	ZONE 15 (HUDSON STRAIT)	ZONE 16 (NW-HUDSON BAY)
Type A	June 25 - Nov. 30	June 25 - Dec. 5	June 20 - Nov. 20
Type B	July 1 - Nov. 30	July 1 - Nov. 30	June 20 - Nov. 10
Type C	July 1 - Nov. 25	July 1 - Nov. 25	June 25 - Nov. 10
Type D	July 10 - Nov. 10	July 5 - Nov. 10	July 1 - Oct. 31
Type E (Non-Ice Strengthened)	July 20 - Oct. 31	July 20 - Nov. 5	July 1 - Oct. 31

Source: Sailing Directions . Labrador and Hudson Bay . 5th Edition . 1983

already done by Canadian insurers. It is too early, however, to provide information on the cost of insurance under the new arrangements since this change was introduced in the autumn of 1985 and no data are yet available.

As indicated in Exhibit 4.1 and discussed in sub-section 1.3.1, AWPPA regulations call for vessels travelling to and from the Port of Churchill at the end of the existing season to be out of AWPPA Zone 14 by October 31st unless they are ice strengthened. Since the eastern limit of Zone 14 is approximately a two day sail from Churchill, non-ice strengthened vessels would have to leave the Port of Churchill by October 29th. Vessels that are ice strengthened and that fall into the AWPPA Type D category (Lloyd's Ice Class III) must clear Zone 15 by November 10th. This implies departure from Churchill by November 6th. An AWPPA Type C vessel (Lloyd's Ice Class II) must clear Zone 15 by November 25th and therefore must depart from Churchill by about November 21st. Between 3½ and 4½ days of sailing time between Churchill and Cape Chidley (depending on lateness in the season) are provided in our economic analyses (Chapter 7), to deal with delays due to ice conditions. During years with particularly heavy ice, more than one additional day may be required as the extended season progresses.

Although the AWPPA limits on navigation have been in place for a number of years, the effective length of the season at Churchill has not increased to take advantage of these limits. This has been due to potential problems with icing conditions and tug operations within the Port and, more importantly, because of the problems in obtaining insurance for the voyage after late October. It has also reflected the lack of perceived need to extend the season into November given the current volumes of grain moving through the Port.

4.2 ICE ASSESSMENT

There are four sections with differing characteristics with respect to ice conditions en route to the Port of Churchill - the eastern approaches to Hudson Strait, the Strait itself, the section south of Foxe

Channel and the route across Hudson Bay to the Port of Churchill. Ice conditions within these four sections also differ at the start and end of the shipping season. The four sections were subdivided into seven route segments as illustrated in Exhibit 4.2 to assist in estimating ice coverage.

4.2.1 Start of Season

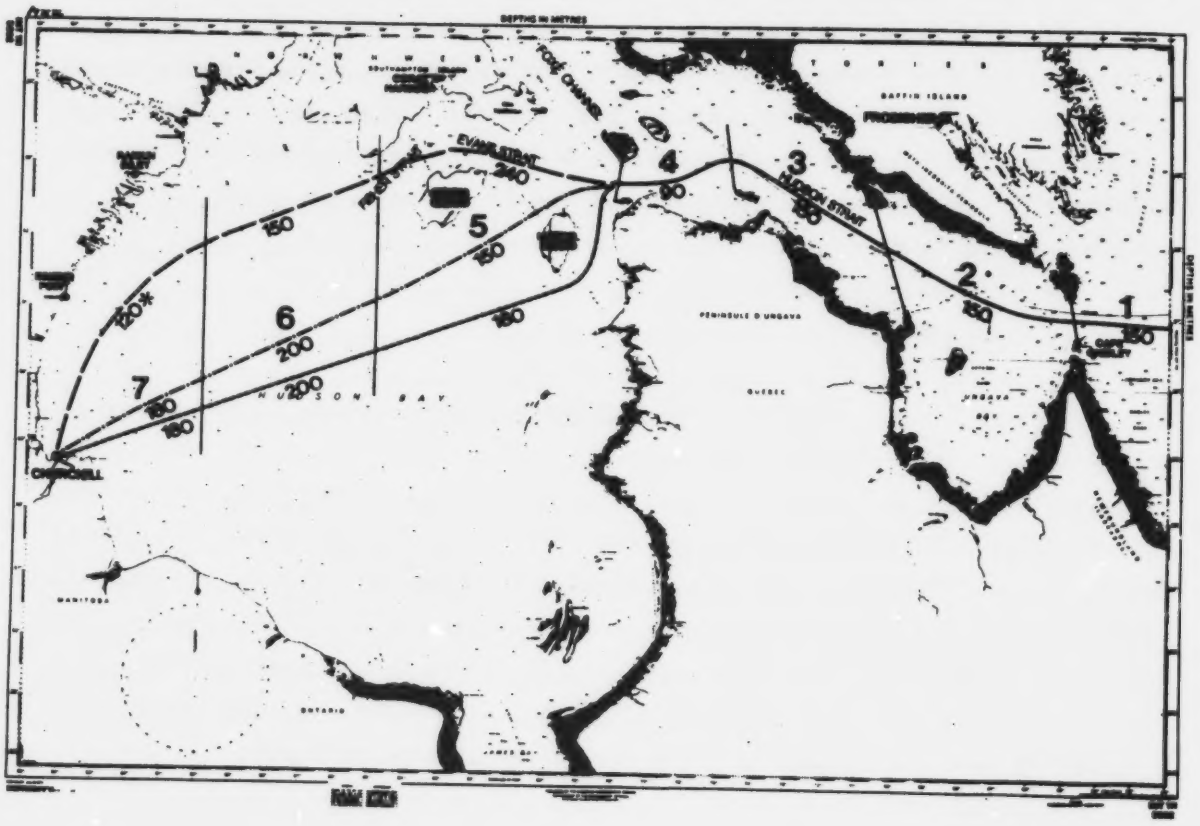
Approaches

As a vessel approaches Hudson Strait in mid-July it may first encounter the ice stream moving down the Baffin coast from Davis Strait. This is composed of mainly first year floes averaging 1.25 to 1.75 m in thickness and usually in the range from 200 to 800 m in length. In one year out of five, up to one tenth old floes 2.5 to 3.0 m thick and 100-500 m in length may be intermixed with the first year ice. There are also numerous icebergs and bergy bits. These latter hazards are also found in eastern Hudson Strait (about as far west as longitude 70 degrees W). They move westward along the Baffin Island coast, cross over to the southern side of the Strait and then return to the Atlantic across the mouth of Ungava Bay. Their numbers are greatest in early summer (June and July) but they decrease steadily in frequency until December or January. These are hazards the ship master must be wary of but they are never present in sufficient numbers to hinder navigation.

On July 23 the median ice edge of the Baffin ice stream is near longitude 64 degrees W but it can be as far east as 62 degrees W. Ice coverage is usually low - in the 1-4 tenths range but again in severe years it may reach 7-8 tenths for a few days. The floes are in motion in response to the wind and a south flowing current, they are melting and although they may cause delay, there is no danger of prolonged entrapment. This impediment to shipping decreases quickly and is no longer present on the average by July 30 although a few floes can linger until as late as mid-August.

exhibit 4.2

SEASONAL SHIPPING ROUTE SEGMENTS



START OF SEASON ROUTE

MID - SEASON ROUTE

END OF SEASON ROUTE

* DISTANCES IN NAUTICAL MILES

SOURCE : W. E. MARKHAM

Hudson Strait

In Hudson Strait the ice is also first year type. The presence of old floes is rare and thicknesses are reduced to 1.0 to 1.5 m. Open leads are very common along the Baffin shore and congested ice conditions are usually confined to Ungava Bay and the Quebec coast in late July. This area too, clears rapidly in late July and early August. In general there is an eastward transport of ice in the strait but very little is carried into it from Hudson Bay.

Foxe Channel

The area south of Foxe Channel from longitude 77 degrees to 81 degrees W is probably the most difficult zone for navigation at the beginning of the season. Here, one encounters ice drifting out of Foxe Basin, identifiable by its brown discolored and deformed floes, as well as the floes from the waters around Coates and Mansel Islands. Salisbury, Nottingham and Southampton Islands can provide lee areas from the general northwest to southeast ice motion but there remain some exposed areas where navigation can be difficult. Again, melting provides quite rapid clearing in the last week of July and the first week of August.

Hudson Bay

The best route to Churchill in July lies north of Coates Island to the vicinity of 62 degrees 30' N 80 degrees W and thence direct to Churchill (Exhibit 4.2). This is the result of the prevailing northwest winds and the early clearing which results. Indeed, navigation northward from Churchill can usually begin by mid-July, even before the Foxe Channel area becomes passable by commercial vessels. By mid-August, the shortest route across the Bay becomes easily navigable and this remains so until freeze up.

The ice conditions that have occurred during the period July 6th to August 9th over the years 1959 through 1983 are illustrated in Exhibit

4.3. The exhibit indicates what proportion of the route from Cape Chidley to the Port of Churchill had what type of ice coverage. The final graph in the exhibit illustrates the trends in ice coverage for the best, mode, average, 80th percentile and worst years for each week. The graphs in Exhibit 4.3 are based on the data tabulated in Appendix A.

A review of Exhibit 4.3 indicates that on July 9th the average extent of all types of ice coverage is in the range of 400 to 500 nautical miles over the total route length of 1,150 nautical miles. Approximately 150 miles of the route has a coverage of 7 tenths or greater on average. Under such conditions, the sailing time between Cape Chidley and Churchill would increase by approximately 40 hours over a base time of 90 hours due to delays caused by the ice conditions.

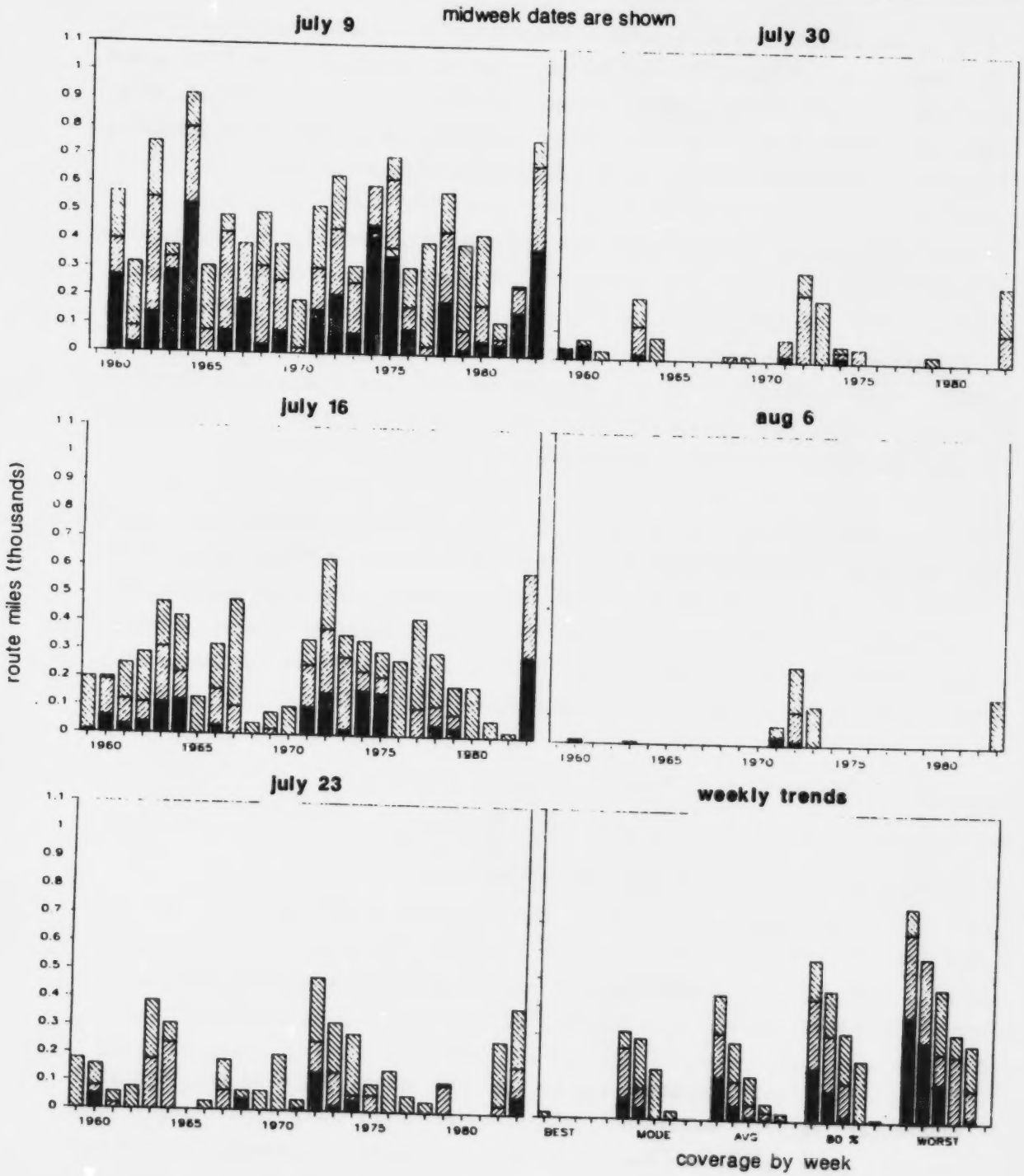
The extent and severity of ice coverage drops significantly during the following two weeks and by July 23rd only 160 miles of the route is covered on average resulting in average delays of approximately six hours. The hours of delay that might have occurred in each of the 25 years from 1959 to 1983 as a result of ice conditions were estimated based on the following assumptions re vessel speed:

- o open water - 13 knots
- o 1-3 tenths first year ice - 10 knots
- o 4-6 tenths first year ice - 8 knots
- o 7-8 tenths first year ice - 5 knots with icebreaker escort
- o 9-10 tenths first year ice - 3 knots with icebreaker escort

The last two speeds assume that the vessel would be provided with icebreaker escort. Additional delays may occur in these conditions if the ice is under pressure due to winds or currents. Icebreaker escort may also be required under conditions of 4-6 tenths ice during July depending upon the thickness of the ice.

exhibit 4.3

ICE COVERAGE EN ROUTE START OF SEASON



The delays which would have occurred given these assumptions for the five weeks in July and August during the 25 years of ice conditions assessed are tabulated in Exhibit 4.4. The exhibit illustrates that even with icebreaker escort over sections with significant ice coverage, minimum delays of one to five days might have been experienced if vessels were to travel during the week July 6-12. This delay would have been added to a base sailing time of 3.7 days. Additional delays of one to three days may be caused if pressure conditions develop. By the following week, the expected delay drops to under one and one-half days except for two out of 25 years. One further week eliminates all extreme values of delay with most values being six hours or under. This trend continues until the week of August 3-9 during which there was little or no expected delay in almost all of the years.

It should be noted that even during the worst conditions for the week July 6-12, the maximum expected delay of five days represents only an increase of less than 20% over a typical overall round trip time of 27 days (22 days sailing and five days in the Port).

4.2.2 End of Season

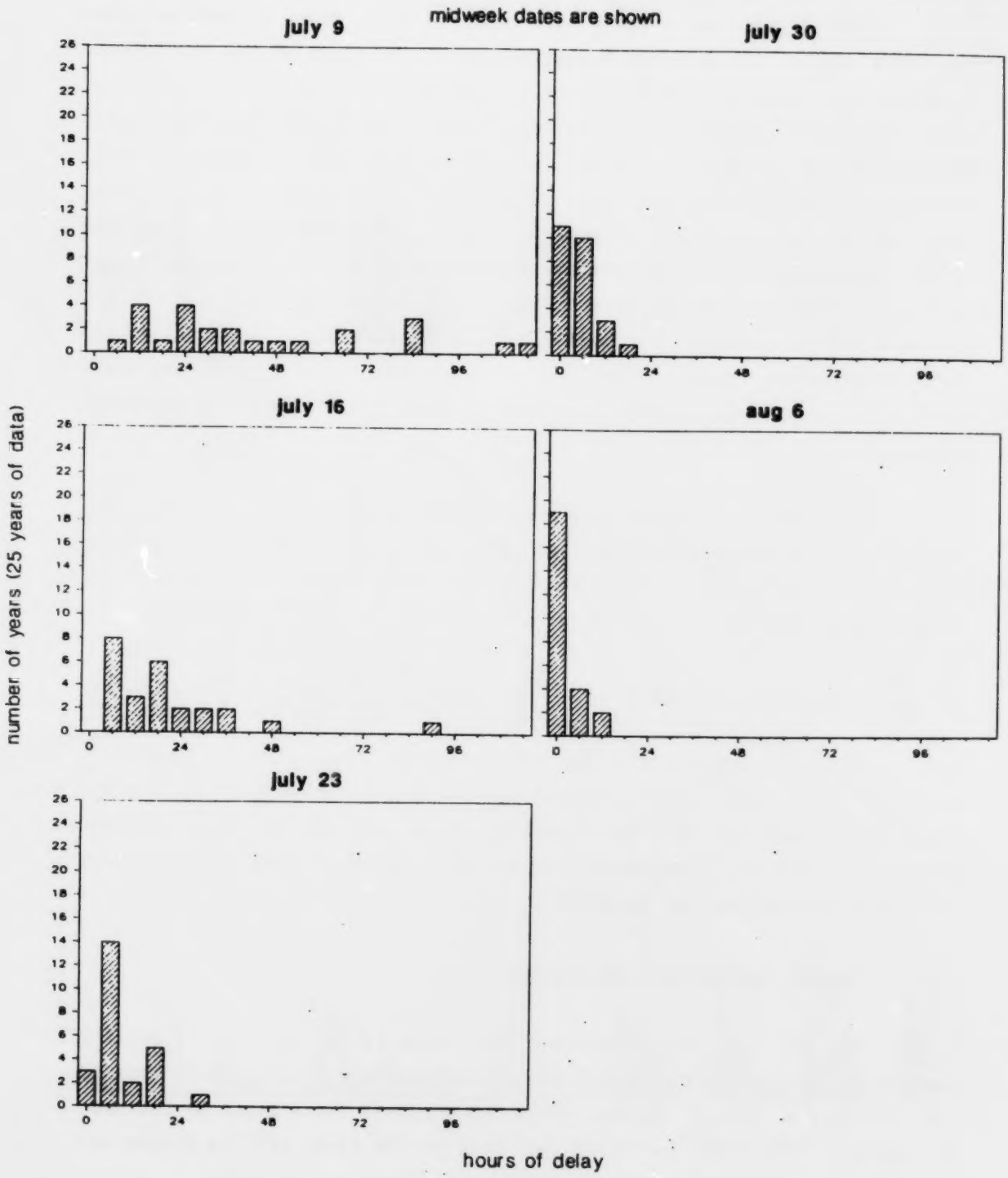
Climatic limitations on end-of-season navigation at Churchill have, in the past, been dictated by ice conditions in the Port itself. Since the diversion of the Churchill River in 1980-81, this has been greatly reduced in importance and the en route conditions indicate that substantial extensions are feasible.

Hudson Strait and Foxe Channel

Up to the end of November, the route to the Atlantic is usually open water but ice from Foxe Basin can intrude and cause difficulties in the Nottingham Island region. This has occurred three times in the past 25 years. The ice is first year type in its final melting stages and although coverage may reach 8 tenths, the floes are in motion - usually eastward, and conditions are extremely variable. During severe years of

exhibit 4.4

EXPECTED DELAY DUE TO ICE
START OF SEASON



these intrusions icebreaker escort may be needed from Coates Island to near Salisbury Island (about 100 miles) but the threat remains confined to this restricted area until other factors affecting the close of the season begin to predominate.

The ice stream down the Baffin Island coast from Davis Strait has been a factor only once in 25 years and that developed in early November (1963) and again the area affected was limited in extent and the general freeze-up soon became the dominating factor.

Hudson Bay

The pattern of ice growth in the fall in Hudson Bay is closely related to the geography and weather systems of the Central Canadian Arctic. Freeze-up in the Arctic progresses southward more quickly in the area between Banks Island and Baffin Island because the waterways are partly ice covered and not particularly broad. To the west, the open Beaufort Sea is a delaying factor while to the east, Baffin Bay serves the same function. The result in Hudson Bay is that freeze-up begins in the northwestern corner, it spreads eastward to Foxe Channel and southward towards Churchill and then begins to develop seaward. This means that the critical route section for late season navigation is from the Port of Churchill across Hudson Bay to the west part of Hudson Strait. It is clear from this ice growth pattern that when the shortest route from Churchill to Hudson Strait becomes affected by ice around Coates Island, it is advisable to divert the track to pass south of Mansel Island and thence northward to Hudson Strait. This can add one to two weeks to the easily navigable period.

Details on the ice conditions and expected delays are given week by week for the period October 12 - December 7 in Exhibits 4.5 and 4.6. The estimates of vessel delay are based on the following assumptions for average operating speeds:

- open water - 13 knots

exhibit 4.5

ICE COVERAGE EN ROUTE
END OF SEASON

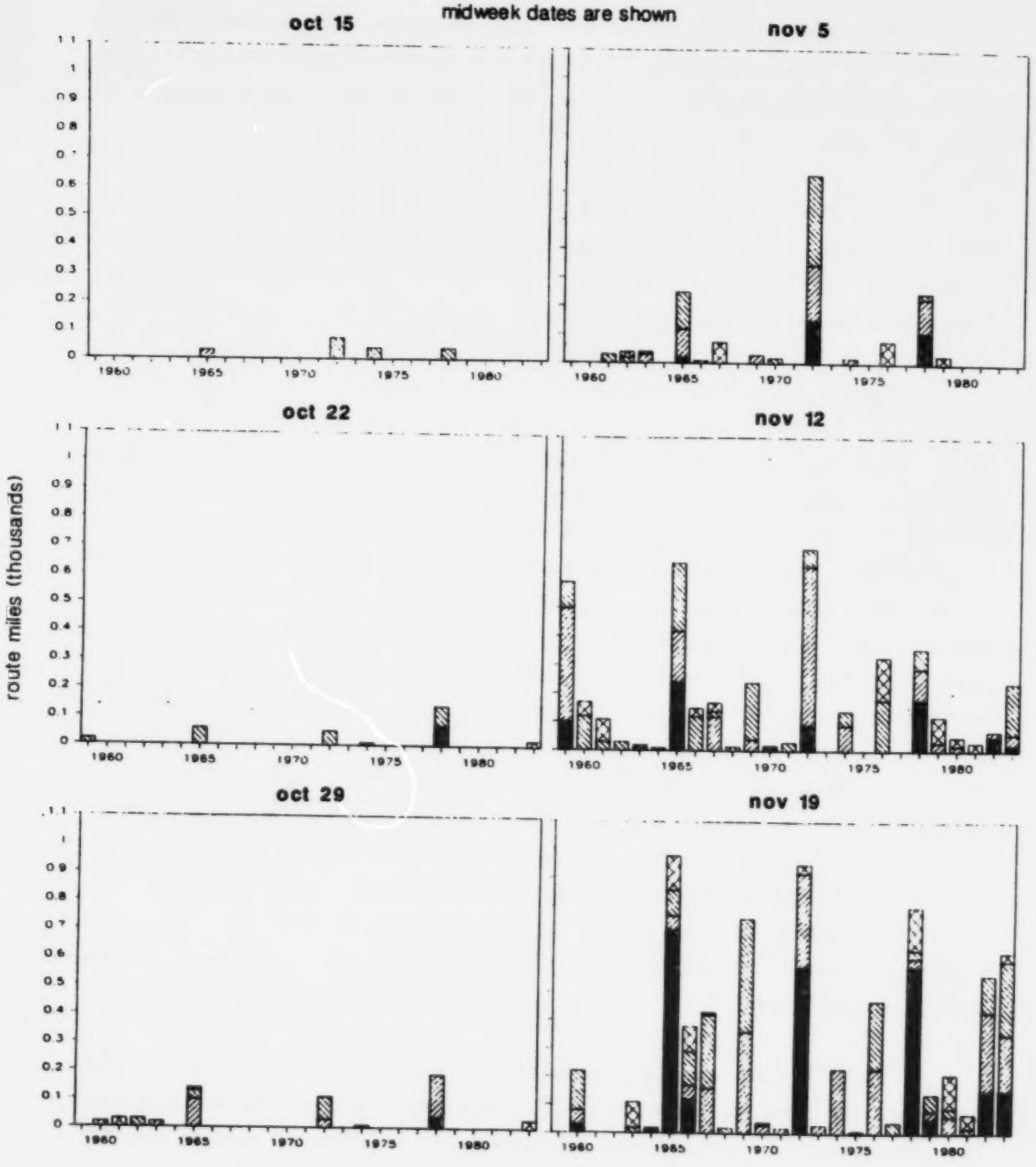
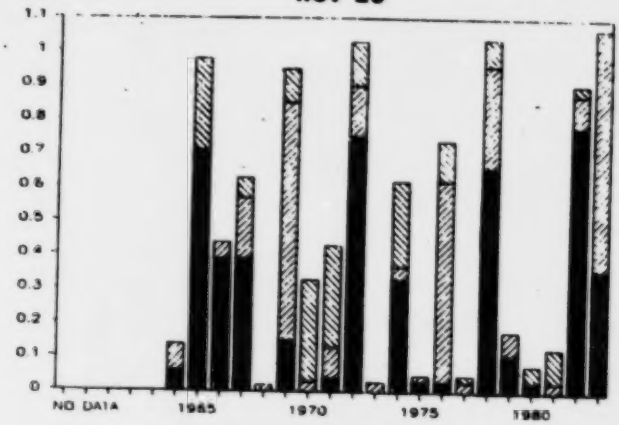


exhibit 4.5 cont'd

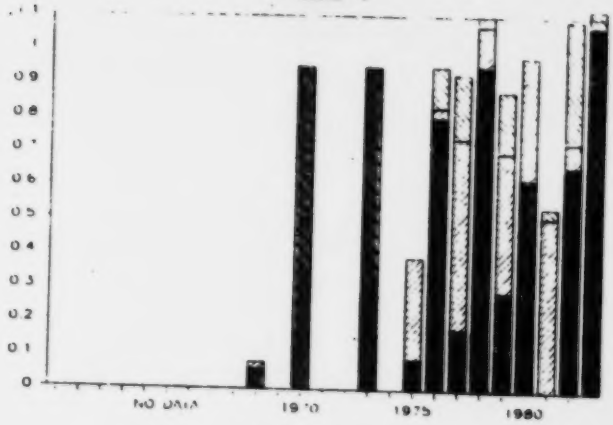
ICE COVERAGE EN ROUTE
END OF SEASON

midweek dates are shown

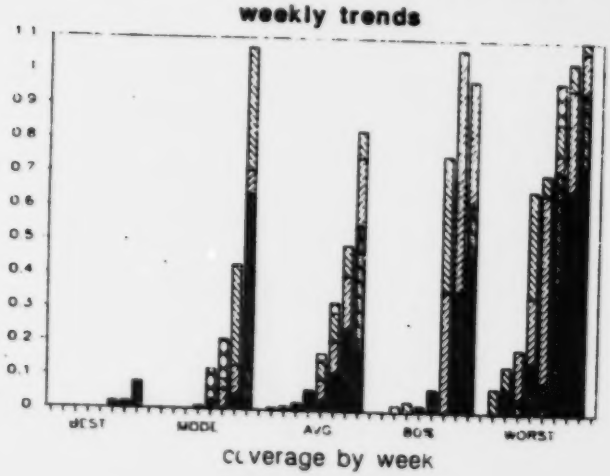
nov 26



dec 4



weekly trends



ICE COVERAGE (tenths)

NEW		9-10	7-8	4-6	1-3
FIRST YEAR	9-10	7-8	4-6	1-3	

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exhibit 4.6

EXPECTED DELAY DUE TO ICE
END OF SEASON

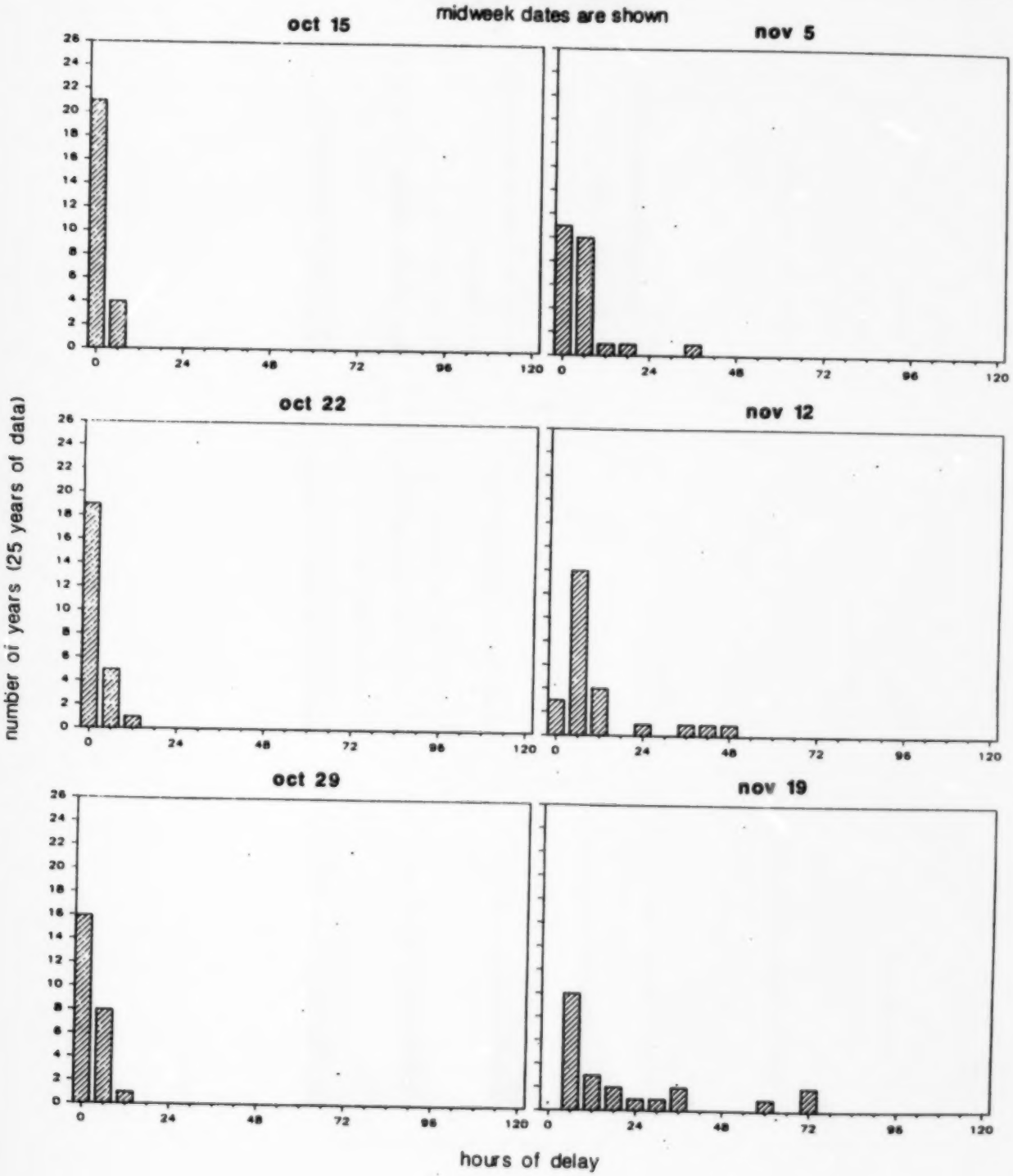
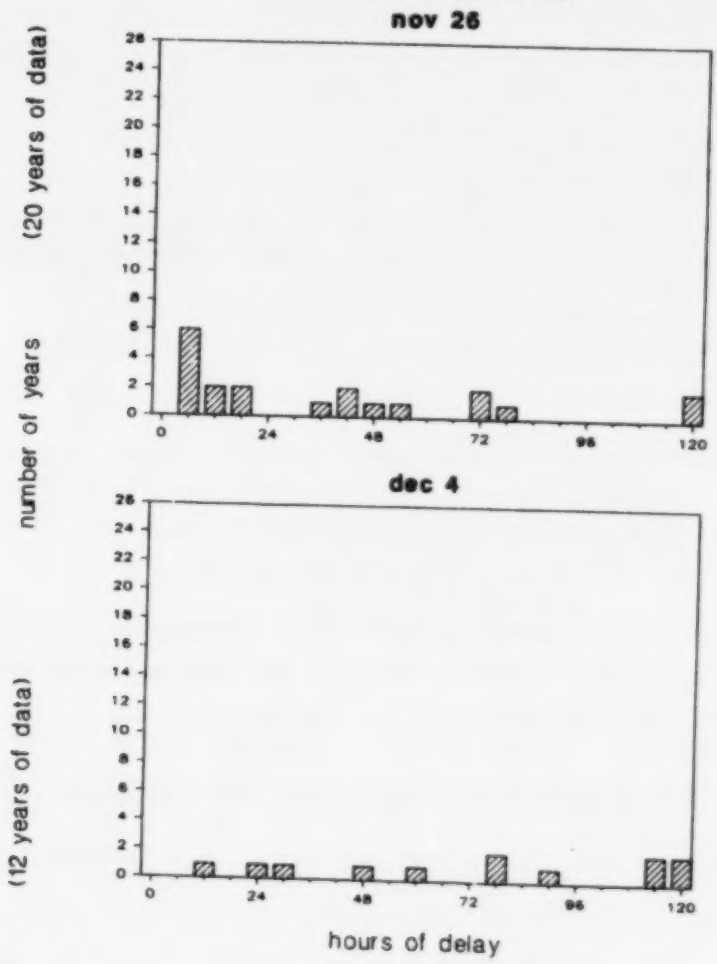


exhibit 4.6 cont'd

EXPECTED DELAY DUE TO ICE
END OF SEASON

midweek dates are shown



- 1-2 tenths new ice - 12 knots
- 4-6 tenths new ice or
  1-2 tenths first year ice - 10 knots
- 7-8 tenths new ice or
  4-6 tenths first year ice - 8 knots
- 9-10 tenths new ice or
  7-8 tenths first year ice - 6 knots with icebreaker escort
- 9-10 tenths first year ice - 4 knots with breaker escort

For equivalent ice coverage, sailing speeds in the spring are lower than in the late fall, reflecting differences in ice thickness and composition.

The last two speeds assume that icebreaker escort would be provided. This escort service may also be required under conditions of 4-6 tenths first year ice depending upon factors such as:

- winds and currents which create pressure conditions;
- horsepower and ice strengthening of the commercial vessel.

Under unfavorable winds which result in pressure conditions in the ice flows, additional delays may occur due to either lower speeds or time spent waiting for conditions to improve.

The data on which these exhibits are based are contained in Appendix A.

The expected delays presented in Exhibit 4.6 do not become noticeable until the week of November 16-22. By that week, expected delays are greater than one day long in six out of 22 years, and up to three days long in two of 22 years. The ice conditions thereafter lead to an expected delay of up to five days in two out of 20 years by the week November 23-29 and a delay of over one day in 10 out of the 20 years for which data were available. For the first week in December, only 12 years

of data were available. During seven of these years estimated delays were in excess of three days and in two years estimated delays were in excess of five days. As noted earlier, a delay of five days represents an increase of about 20% in the total voyage time (including five days in Port), increasing it from about 27 to 32 days. The cost of delays to vessels was included in the economic analysis.

The geographic locations of the ice edges that occur in late November and early December in the Hudson Bay and Hudson Strait areas are illustrated in Exhibits 4.7 to 4.9. Exhibit 4.7 presents the median, maximum and minimum edges of all types of ice including new, slush and gray ice with thicknesses up to 15 cm. Exhibit 4.8 presents the median edges of first year ice having a thickness of 30 cm or more. Exhibit 4.9 presents the maximum edge of first year ice.

4.3 OTHER CLIMATIC FACTORS

There are a number of other climatic factors in addition to ice conditions that may have an impact on season extension at the Port of Churchill. These factors include daily temperatures, wind speeds and directions. These factors have a potential impact only at the end of the current shipping season primarily by delaying vessel loading or departures.

Maximum and minimum mean daily temperatures at several locations along the route between the Port of Churchill and Cape Chidley are presented in the table below:

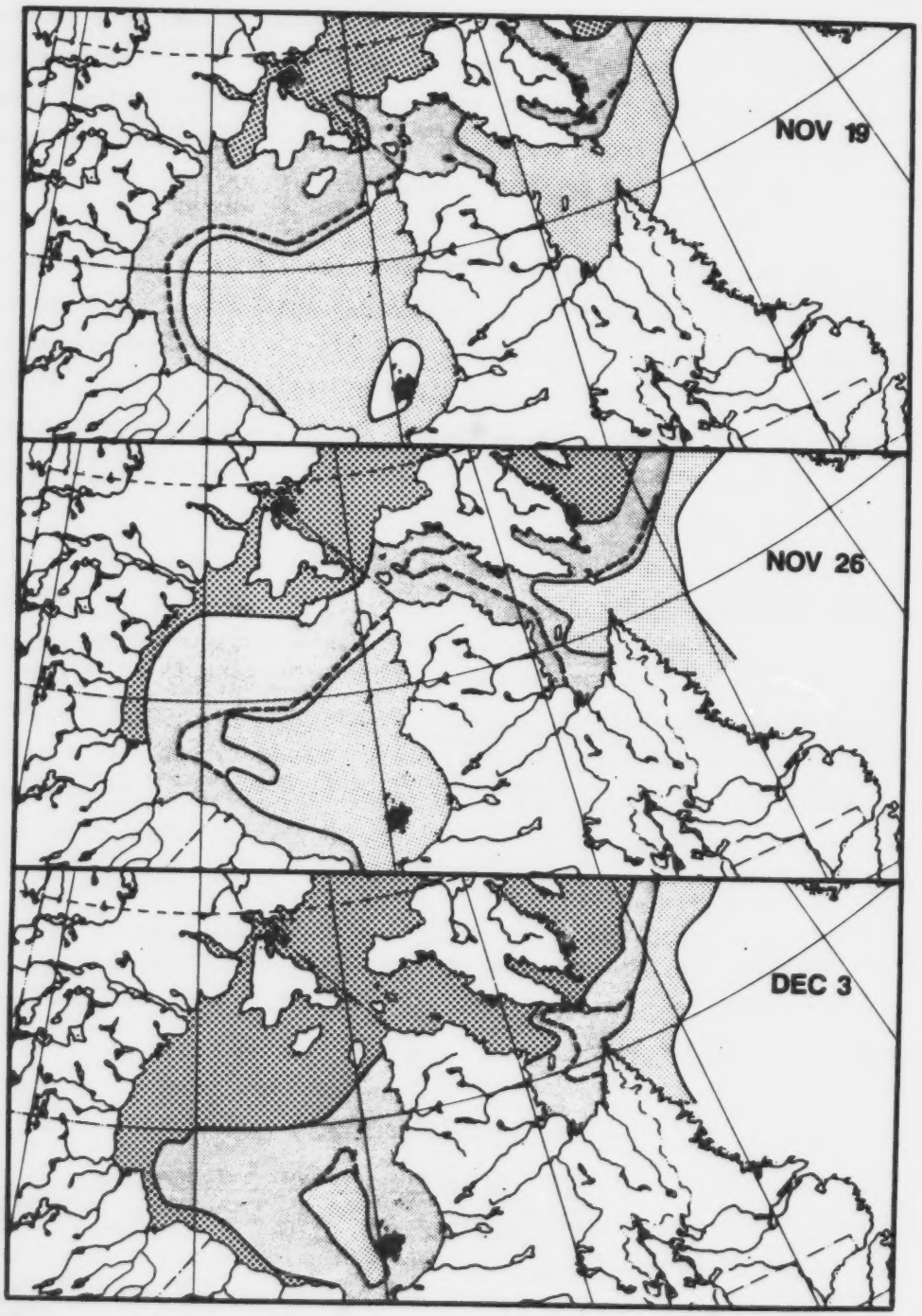
Mean Daily Temperatures

Location	October		November	
	Maximum	Minimum	Maximum	Minimum
	(Degrees C)		(Degrees C)	
Churchill	1	- 4	- 8	-16
Chesterfield Inlet	-3	- 8	-14	-21
Coral Harbour	-4	-11	-13	-22
Nottingham Island	-1	-5	- 7	-13
Resolution Island	0	-3	- 4	- 8

exhibit 4.7

ICE EDGES – END OF SEASON

SOURCE : W. E. MARKHAM



minimum **median** **maximum** **median edge of 7 tenths ice**

(this includes NEW, SLUSH, and GREY ice all under 15cm thick)

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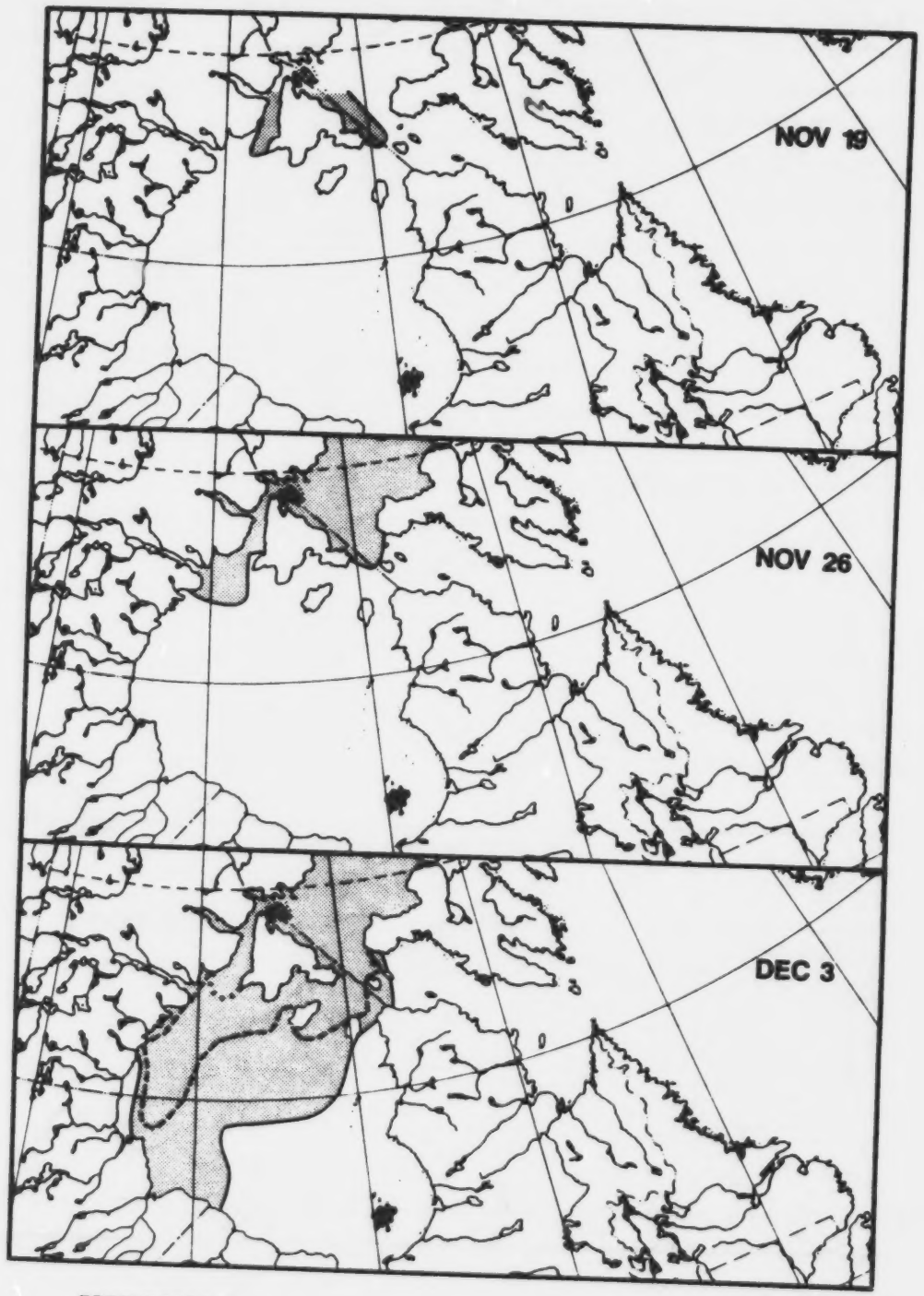
exhibit 4.8

FIRST YEAR ICE – MEDIAN EDGE END OF SEASON

SOURCE : W. E. MARKHAM



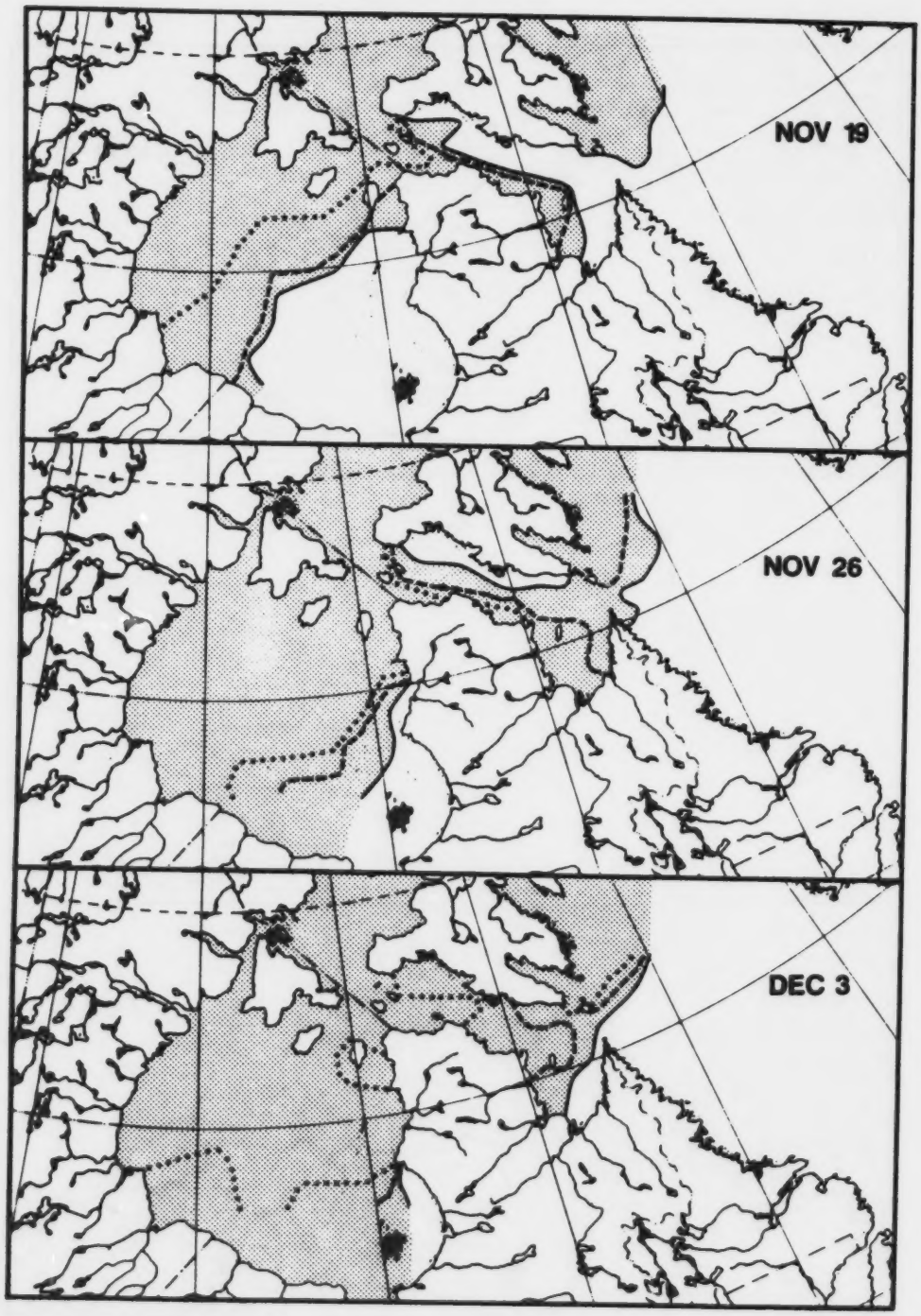
---------- maximum of 2 tenths ice

..... maximum of 7 tenths of 30cm (or more) ice

exhibit 4.9

FIRST YEAR ICE - MAXIMUM EDGE END OF SEASON

SOURCE : W. E. MARKHAM



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maximum of 2 tenths ice

.....

maximum of 7 tenths of 30cm (or more) ice

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The coldest temperatures are recorded at Chesterfield Inlet and Coral Harbour; however, at the end of the season vessels would tend to cross Hudson Bay at about latitude 60 degrees north, thereby travelling well south of these positions. Both Nottingham Island and Resolution Island are close to the likely routing of vessels travelling from Churchill to Cape Chidley and are therefore reflective of the temperatures that may be experienced by vessels as they are passing through Hudson Strait. Nottingham Island temperatures are considered to be reasonably representative of conditions offshore in Hudson Bay.

Exhibit 4.10 tabulates the average wind direction and speed for Nottingham Island for the months of July through December. The highest average wind speeds occur during the months of October and November with north and northwest as the dominant directions. The highest average wind speeds from a single direction are 18.1 and 20.4 miles per hour for the months of October and November, respectively. In both cases the winds are from the southwest with a frequency of 8%.

The frequency of occurrence of gale force winds (Beaufort Force 7-9) during the months of October and November at selected points along the route between the Port of Churchill and Cape Chidley are as follows:

Frequency of Gale Force Winds

Location	October	November
Churchill	8.5%	13.5%
Coral Harbour	9.0%	14.4%
Resolution Island	5.6%	7.5%
Frobisher	7.5%	7.7%

Both air temperatures and wind speed have an impact on vessel icing. A study of superstructure icing on fishing trawlers proceeding at low speeds indicates that in the offshore temperatures noted above,

exhibit 4.10

WIND DIRECTION & SPEED - NOTTINGHAM ISLAND

DIRECTION	PERCENTAGE FREQUENCY						
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ALL YEAR
N	6	10	9	13	25	16	11
NE	18	30	14	14	18	17	19
E	12	10	10	11	11	4	10
SE	5	7	9	7	4	1	5
S	16	9	9	10	7	10	12
SW	20	10	11	8	8	18	12
W	14	12	11	14	8	16	12
NW	7	10	23	22	16	15	16
CALM	2	2	4	1	3	3	3

DIRECTION	AVERAGE WIND SPEED IN MILES PER HOUR						
	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	ALL YEAR
N	10.2	10.2	9.1	9.1	9.0	8.0	8.8
NE	13.7	15.0	12.3	11.9	13.2	13.1	12.9
E	10.4	11.1	9.9	12.0	10.9	11.9	11.0
SE	10.6	9.5	12.5	15.0	15.9	10.1	11.2
S	10.0	10.7	11.9	15.8	15.2	11.7	12.2
SW	9.5	9.4	12.5	18.1	20.4	14.8	13.9
W	7.7	8.4	8.7	13.3	12.3	10.0	10.0
NW	10.6	10.4	12.6	15.4	15.9	8.8	11.4
All Directions	10.1	11.2	10.9	13.4*	12.6	10.8	11.2

NOTE: Data is from the period 1956-70; the station was closed in August, 1970.

* On average October rather than November or December has the highest average wind speed

Source : Atmospheric Environment Services Climatological Data

moderate icing (4 to 7 cm per day) would likely be encountered in Beaufort Force 6-7 winds and heavy icing (7 to 14 cm per day) in Force 8 winds. Lower accretion rates should be expected in larger vessels but higher ones at greater speeds.

Daylight hours vary from 10 per day at Churchill in mid-October to about 7½ per day in mid-November. At latitude 62 degrees north the duration is about 30 minutes less in mid-November. Duration of astronomical twilight in these latitudes is almost two hours and civil twilight is about 40 minutes. The number of daylight hours are not normally a factor during the months of October and November since most of the ice coverage consists of new and/or gray ice. These types of ice would not damage ocean going vessels. The limited daylight hours may pose additional hazards in late November and early December if the ice coverage includes substantial first year ice (greater than 30 cm thickness). Under such conditions, icebreaker escort may be required to facilitate night time navigation. Climatic factors are highly correlated with season of the year and hence icing conditions. Their average effect has been factored into the estimated sailing speeds for the various ice condition categories at the beginning and end of the season.

4.4 VESSEL AVAILABILITY

In considering the extension of the season at the Port of Churchill beyond the current operating period, the availability of ice strengthened vessels must be considered due to the operating requirements of AWPPA. Exhibit 3.4 tabulates some of the characteristics of the grain vessels that served the Port of Churchill during the years 1977 through 1984. As illustrated in the exhibit, 64% of the vessels using Churchill during that period for which registry information was available were ice strengthened. Fifty-two percent were both ice strengthened and from Communist Block countries. The specific countries from the Communist Block that used the Port of Churchill during that period include: USSR, Poland, Czechoslovakia, Bulgaria and Yugoslavia. Most of the ice strengthened vessels using the Port of Churchill in the past would fall into the Type D category of AWPPA.

Local trade commissions of the different countries referenced above were contacted to determine the number of ice strengthened vessels registered in each country. The following information was provided by the trade commissions:

	Ice Strengthened Vessels
USSR	Approx. 1,000
Poland	30-40
Czechoslovakia	14
Bulgaria	10-20
Yugoslavia	10-15

Other countries whose vessels have used the Port of Churchill and who have ice strengthened vessels include Norway and Finland. According to the 1985/86 Lloyd's Registry of Ships, there are 24 ice strengthened bulk carriers with a capacity greater than 20,000 tonnes registered in Norway. There are an additional eight ice strengthened vessels which have onboard self-cleaning facilities and which can transport ore, oil or bulk commodities such as grain. In Finland, there are 12 ice strengthened bulk carriers under registry. In the case of Swedish flag ships, there is one ice strengthened bulk carrier.

All of the ice strengthened bulk carriers referred to above from the Scandinavian countries were built in the period 1970 to 1984. Therefore, these ships are less than 15 years old and should not be subject to age related insurance premiums.

In Canada, Fednav is the only Canadian shipping company that owns and operates ice strengthened vessels under Canadian registry. They have 10 vessels which fall into the AWPPA Type B category and which have dead weight tonnages (DWT) of 28,000 to 30,000.

The significant proportions of ice strengthened vessels that have used the Port of Churchill in the past indicate that the availability of Type D vessels at a minimum should not pose a problem to season extension, which would allow a season of about 118 days within the AWPPA regulations as applied to Churchill (July 12th to November 6th). The availability of Type C and Type B vessels, which would be required for season extension into late November and early December, is less certain. At that time of year, there may be additional demands on these types of vessels in both Canada and elsewhere thereby reducing availability. Since only two vessels are required for each week of season extension under the base case scenario, it is likely that vessel availability could be resolved, possibly by long term CIF charter if season extension into late November and early December is found to be desirable.

4.5 ICEBREAKER AND RELATED REQUIREMENTS

Currently, the Canadian Coast guard operates icebreakers in both Hudson Strait and Hudson Bay at the start and end of the shipping season. The duties performed by these vessels include the placement and removal of navigational aids, monitoring of ice conditions, and provision of escort services on an as required basis. Because of the limited amount of shipping which currently occurs at the start and end of the AWPPA shipping season, the icebreakers are not used extensively for escort duties.

The icebreakers in Hudson Bay and Hudson Strait during the month of July are typically reassigned to duty in the High Arctic in early August. These vessels return to the Hudson Strait area by mid-October. After the shipping season ends in Hudson Bay and Hudson Strait, the icebreakers typically return to Quebec City for one to three weeks of maintenance before deployment in the St. Lawrence and Saguenay Rivers. Discussions with the Canadian Coast Guard indicate that two heavy icebreakers are available for operations in Hudson Bay and Hudson Strait during the month of July and at least one is available at the end of the season from mid-October to December 7th. A second icebreaker could be

made available at the end of the season if warranted by heavy ice conditions.

4.5.1. Saguenay and St. Lawrence River Operations

Background material was obtained for ice breaking operations on the Saguenay and St. Lawrence Rivers. This information provides a useful illustration of the operational procedures used by the Canadian Coast Guard in ice breaking and escort operations. On the Saguenay River, ice begins to form in the middle of December and attains a depth of 30 to 40 cm by the end of the month. During this period a medium size icebreaker (4,000 horsepower) is used for escort duties. From the beginning of January, a heavy icebreaker is brought into service. During the months of January and February ice continues to form rapidly on the river, attaining a depth of 75 to 90 cm by the end of February. Throughout this time the heavy icebreaker performs escort duties. Ice breaking duties as opposed to escort services are usually undertaken from mid-March to early April.

During the winter months, the Saguenay River is covered solidly by ice over a distance of 35 miles. Since the ice is solid and stationary between the banks of the river, there are no pressure conditions which are normally caused by winds, currents and tides. The river is very deep and there are no major obstacles to navigation, therefore escort and icebreaking operations can be undertaken during both day and night.

At the beginning of the winter season, in about the middle of December, the Alcan Corporation located in Port Alfred prepares a schedule for the Coast Guard indicating the dates and names of the vessels that are expected in the Port. This schedule permits the icebreaker captain to plan the season's operations.

The escort work on the Saguenay River consists of breaking open a track over a distance of 35 miles. Since there are no tugs in operation

during the winter at Port Alfred, the icebreaker must also clear the ice which develops alongside the dock in Port Alfred in order to facilitate the docking of commercial vessels. Because of the relatively short distance involved (35 miles) and the relatively low volumes of traffic, there is no need to convoy vessels on the Saguenay River. It should be noted that to date the Coast Guard has not charged for the services provided by icebreakers on the Saguenay River.

On the St. Lawrence river, operations begin in about mid-December and normally all vessels of the icebreaker fleet of the Laurentian region are operational by this time. One heavy icebreaker is based in Montreal to assist vessels leaving the seaway. Normally these operations are completed by the end of December. The main job of the heavy icebreakers during the remainder of the winter season is to prevent the formation of ice dams on Lake St. Pierre and at the bridges in Quebec City. On Lake St. Pierre when the winds are from the east the effects of the river current are nullified causing ice floes to build up and making navigation within the channel very difficult. Often two heavy icebreakers are used to assist navigation on the lake, primarily during the months of January and February. A heavy icebreaker based in Quebec City monitors the movement of ice floes near the bridges since the effects of tides and wind can result in the formation of ice dams. This danger is most severe during the months of January and February.

When conditions on the St. Lawrence are difficult, almost all commercial vessels request assistance from icebreakers when navigating near the bridges in Quebec City. This is because the channel in these areas is relatively narrow and often the ice is piled up to a depth of 15 to 20 feet at bridge piers.

As in the case of the Saguenay River, the Coast Guard has not charged commercial vessels for the assistance provided during winter months on the St. Lawrence.

4.5.2 Operational Assumptions

In order to estimate the extent of icebreaker assistance required at the start and end of the shipping season to Churchill, a number of assumptions were made with respect to the ice conditions under which escort services would be required and the average speed for icebreakers and escorted vehicles in the different ice conditions. At the start of the season it was assumed that non ice-strengthened vessels would require icebreaker escort wherever ice coverage was 4 tenths or greater. On the other hand, it was assumed that ice strengthened vessels would require escort under conditions of 7 tenths coverage or greater. The actual requirements of a specific vessel will depend upon both the degree of ice strengthening of the vessel and its horsepower.

At the end of the season, it was assumed that non-ice strengthened vessels would require icebreaker escort over sections where ice coverage was 7 tenths or greater of new, slush or grey ice. It was also assumed that the use of non-ice strengthened vessels would not be advisable once significant sections of 9 to 10 tenths ice have developed along the route. These conditions almost always only occur after the dates which limit navigation for non-ice strengthened vessels under AWPPA.

For ice strengthened vessels, it was assumed that escort would be required under conditions of 7 tenths or greater coverage of first year ice or 9 tenths or greater of new, slush or grey ice. As the ice conditions become more severe, it becomes inadvisable to use type D or C ice strengthened vessels even if icebreaker escort is provided.

Icebreaker escort would not be required in all situations called for under these assumptions; however, the actions of an icebreaker can help to reduce delay through sections of heavy ice. In estimating icebreaker requirements, it was assumed that icebreakers would be used in this role.

In addition to the extent of ice coverage, the existence of pressure conditions within the ice will also have an impact on icebreaker escort requirement. If wind and tide action results in pressure conditions, additional delay due to either slower operating speeds or a wait for conditions to change will result. Obviously the risk of experiencing such conditions increases with the extent of ice coverage.

Exhibit 4.11 summarizes the extent to which icebreaker escort would be required in years with good, moderate or heavy ice conditions. This exhibit is based on the above assumptions and a review of ice conditions during the past 25 years along the route from Churchill to Cape Chidley. Good and heavy ice years each represent one year out of five, while moderate years represent the remaining three out of five years. As indicated in the exhibit, during some weeks of the season escort requirements would be less than 100 nautical miles. In those situations, particularly during the month of July, it may be appropriate to wait for conditions to improve if escort services are not immediately available. On the other hand, in situations where escort requirements exceed 400 to 500 miles, it may be appropriate for the icebreaker to escort a convey of two or three commercial vessels at one time over the entire route.

4.5.3. Icebreaker Operating Costs

The principal incremental costs involved in extending icebreaker services in the Hudson Bay and Hudson Strait areas at the beginning and end of the shipping season are additional fuel costs, and crew overtime costs. The salaries and wages of officers and crew onboard the icebreaker are already covered by the annual budgets of the Coast Guard. Furthermore, since extended operations in Hudson Bay and Hudson Strait would not involve any change in the icebreaker fleet size or any additional sailing to reach the area there would be no additional capital costs incurred or any incremental operating costs en route to Churchill. Fuel, salary and fringe benefit costs for the heavy icebreaker in 1985

exhibit 4.11

ICE BREAKER REQUIREMENTS (MILES OF ESCORT)

VESSEL TYPE (AMPPA CLASS)	ICE CONDITIONS	WEEK							
		JULY 6-12	JULY 13-19	JULY 20-26	JULY 27-AUG 2	AUG 3 - AUG 9	MID AUGUST TO MID OCTOBER	OCT 11-18
E	o Good	Outside AMPPA	Outside AMPPA	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort
	o Moderate	o Not Advisable	o No Escort	o Up to 100	o No Escort	o No Escort	o No Escort	o No Escort
	o Heavy Ice	o Not Advisable	o 100-200	o 100-250	o Up to 100	o 100 in worst year	o No Escort	o No Escort
		o Not Advisable	o Not Advisable					
D	o Good	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort
	o Moderate	o 150-300	o 50-150	o up to 50	o No Escort	o No Escort	o No Escort	o No Escort
	o Heavy Ice	o 300-700	o 150-300	o 50-150	o up to 50	o No Escort	o No Escort	o No Escort
C	o Good	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort
	o Moderate	o 150-300	o 50-150	o Up to 50	o No Escort	o No Escort	o No Escort	o No Escort
	o Heavy Ice	o 300-700	o 150-300	o 50-150	o Up to 50	o No Escort	o No Escort	o No Escort

VESSEL TYPE (AMPPA CLASS)	ICE CONDITIONS	WEEK							
		OCT 19-25	OCT 26-NOV 1	NOV 2-8	NOV 9-15	NOV 16-22	NOV 23-29	Nov 30 - Dec 6
E	o Good	o No Escort	o No Escort	Outside AMPPA	Outside AMPPA	Outside AMPPA	Outside AMPPA	Outside AMPPA
	o Moderate	o No Escort	o No Escort	o No Escort	o No Escort	o up to 50	Not Advisable	Not Advisable
	o Heavy Ice	o No Escort	o No Escort	o No Escort	o Up to 100	o Not Advisable	Not Advisable	Not Advisable
		o No Escort	o Up to 50	o 100-300	o Not Advisable	o Not Advisable	Not Advisable	Not Advisable
D	o Good	o No Escort	o No Escort	o No Escort	Outside AMPPA	Outside AMPPA	Outside AMPPA	Outside AMPPA
	o Moderate	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort	Up to 50	100-400
	o Heavy Ice	o No Escort	o No Escort	o 50-150	o No Escort	o 50-200	50-400	Not Advisable
					o 100-250	o 200-800	Not Advisable	Not Advisable
C	o Good	o No Escort	o No Escort	o No Escort	o No Escort	o No Escort	Outside AMPPA	Outside AMPPA
	o Moderate	o No Escort	o No Escort	o No Escort	o No Escort	o 50-200	No Escort	100-400
	o Heavy Ice	o No Escort	o No Escort	o 50-150	o 100-250	o 200-700	50-400	
							400-800	Not Advisable

dollars are as follows:

Fuel Costs

- unit cost	$ 350.00/tonne
- consumption	15 tonnes/day on standby
	50 tonnes/day in 24 hour operation
- cost/day	$ 5,250/day on standby
	$ 17,500/day in 24 hour operation

Officers' Salaries

- unit cost	$ 13.71/hour
- staffing level	22 officers for 8 hours/day
- benefits/overhead	30%
- cost/day	$ 3,120/day

Crew Wages

- unit cost	$ 9.61/hour
- staffing level	40 crew for 8 hours/day
- benefits/overhead	30%
- cost/day	$ 4,000/day

Overtime Premium

- weekend overtime $ 25,000
  (including base pay and overtime for the entire weekend)

As described further in Chapter 7, these costs convert to incremental costs of $25,000 per week for the additional fuel and crew overtime costs to extend icebreaker coverage on the Churchill route at the beginning and end of the season.

4.6 SUPPORT SERVICES

4.6.1 Ice and Weather Advisory Services

The Atmospheric Environment Service and the Canadian Coast Guard operate an ice advisory service consisting of aerial and satellite reconnaissance, ice forecasts, recommended shipping tracks and other relevant information. This is provided by radio from Frobisher Bay and by radio facsimile broadcast from Frobisher Bay and Halifax. It is recommended that all vessels be required to use this service at the beginning and end of the shipping season in Churchill and that ship captains report their positions twice daily to the Coast Guard and cooperate fully with the Ice Information Officer.

Information services provided in the Port of Churchill should be improved by providing access to ice charts, telephone contact with the Ice Information Officer to obtain routing advice and ice forecasts, and a formal mechanism for scheduling icebreaker escorts if required during an extended season. This service could also support coastal resupply operations out of the Port of Churchill.

A further requirement for operations into an extended season should be the mandatory use of ice advisors or suitably qualified captains for any approved operations outside of the limits currently defined by AWPPA. The use of ice advisors is particularly important if significant amounts of first year ice are present along the route.

The extension of shipping operations to and from the Port of Churchill will also require a close monitoring of ice conditions and ice forecasts by those responsible for the scheduling of shipments from the Port of Churchill. Two week forecasts can be developed with sufficient accuracy to enable the determination of icebreaker escort needs and the appropriate scheduling of these services.

Longer range forecasts of four to six weeks could be developed with sufficient accuracy to categorize the type of conditions to be expected as either good, moderate or heavy ice conditions. Forecasts of this length can be made since ice conditions in Hudson Bay and Hudson Strait develop in a predictable pattern. The timing of the early stages of these patterns of development can be used to predict the upcoming ice conditions.

4.6.2 Navigational Aids

As described more fully under Section 5.3 below, radio aids to navigation, and radio communication services are provided by the Canadian Coast Guard to vessels en route between Cape Chidley and Churchill. Information services regarding ice reconnaissance, weather, etc., are available, and cover the entire 17 weeks of the proposed extended season. Since these services are in place, additional services or costs would not be incurred to support the proposed season extension.

Similarly, as discussed in Chapter 7, subsection 7.1.2, the existing land based ranges used as navigational aids for harbour operations at Churchill have been sufficient in the past for vessel movements after removal of the floating buoys due to late season ice. The study team considers that the existing land base ranges will be suitable for the proposed 17 week extended season, but recommends (as noted in Chapter 8) that this situation be monitored if the proposed season extension is achieved, in order to determine whether two additional radar transponders should be installed in the harbour to augment the existing land based ranges.

4.6.3 Search and Rescue (SAR)

There are four Rescue Coordination Centres (RCC's) in Canada, located at Victoria, British Columbia, Edmonton, Alberta, Trenton, Ontario and Halifax, Nova Scotia. Coordination of SAR activities in the study area are split among three RCC's, as follows:

Zone	RCC Location
Churchill	Edmonton
North of Hudson Strait	Trenton
South of Hudson Strait	Halifax

The system is described in the report Flight Planning and Procedures, North Alberta DND Flight Information Document GPH 204.

While search and rescue operations meet a wide range of requirements, their primary area of application in the Arctic is for the air mode and they are, of course, operational during the entire year. Other marine activities (e.g. Arctic resupply, ore movements, Canadian Coast Guard icebreaker activity, etc.), normally occur in the "shoulder periods" of the Churchill season which would be affected if the proposed season extension goes into effect.

For these reasons, the study team is of the opinion that the proposed season extension at Churchill will have no impact on additional requirements for SAR operations or costs. Indeed, the additional vessel activity generated could be of use to the Rescue Coordination Centres by providing additional sources of information to help pinpoint SAR search activities.

4.6.4. Insurance

As noted earlier in sub-section 1.3.1, the availability of insurance is another requirement with respect to en route operations. Given the developments which have occurred this past year, it appears likely that vessels operating within the limits set by AWPPA will be able to obtain insurance for the voyage to Churchill without incurring significant supplemental premiums.

The extension of the season to beyond the current limits set by AWPPA would require changes to the Act. Any such changes would be subject to both an environmental assessment and a review of the safety implications of such actions.

It might be expected that any changes to the Act would be incorporated subsequently in the conditions used by underwriters to determine insurance premiums for vessels travelling to the Port of Churchill. The limits on the shipping season set in AWPPA are blanket restrictions that reflect the capabilities of unescorted vessels in Arctic waters. A rationale for changing the limits set within AWPPA would be the availability of icebreaker escorts and the capability of the Coast Guard to restrict access during years with particularly heavy ice conditions. This would require a more comprehensive vessel monitoring, communication and information service then is now in place, as is discussed further in Chapter 8.

4.7 ENVIRONMENTAL CONSIDERATIONS

The potential environmental impact of season extension was addressed from two points of view:

a) impact on the Port and its immediate environs;

b) impact en route.

The following discussion is based on a 17 week extended season, from July 20 to November 15, as proposed in Chapters 7 and 8 below.

4.7.1 In and Near the Port

Season extension will not require construction of significant facilities, nor would there be any requirement to reconfigure the Port. In the spring, the harbour is open following breakup of the river ice and this occurs well in advance of any practical opening date for the deep sea

shipping season. In the fall, historically shipping activities have already taken place after ice cover has formed in the harbour without any adverse environmental affects being reported. Furthermore, it would appear that the risk of damage to vessels and the associated potential for fuel spillage has probably been reduced in recent years as a result of improved icing conditions resulting from the Churchill River diversion.

4.7.2 En Route

Insofar as en route operations are concerned, the intention is to maintain the frequency of sailings approximately to historic levels of two or three vessels per week. The only significant change envisioned would be that icebreaker assistance would be made available when required to facilitate navigation by vessels at problem locations en route. At season opening icebreaker assistance would be provided in ice which is already melting because of increasing air temperatures, and large expanses of open water exist. In the fall, the role of the ice breakers is to reduce the sailing time of vessels by breaking up ice which is beginning to form. Again, operations would occur during a transition period when large expanses of open water or very thin ice are present.

The Arctic Water Pollution Prevention Act (AWPPA) and related regulations specify vessels operating in the region at different time of the year, as noted earlier. The Act, unlike the regulations existing in the USSR makes no distinction between vessels operating on their own and those escorted by icebreakers. The Soviet practice is to reduce the ice strengthening standard for vessels operating behind icebreakers.

The proposal to provide ice breaker assistance on the Churchill route during the extended season could be considered as providing an additional factor of safety over that already implicit in the AWPPA. The analysis presented earlier in this chapter shows that there are wide seasonal variations in the timing and extent of ice coverage and that, for many of the years for which data was examined, the route was substantially

free of ice well into November. This raises the possibility that vessels of lower ice classification than that specified by AWPPA regulations might be permitted to operate later into the season in selected years. Such operations would represent a departure from the present regulations and would probably require an environmental impact assessment.

The basic recommendations of this study, however, as summarized in Chapter 8 are that the season be extended to the 17 week period described above and that, within that period, the various classes of vessels would operate only within the seasonal limits allowed under the AWPPA regulations. As noted in subsection 1.3.1 and elsewhere in this report, these regulations allow Type E (unstrengthened) vessels to use the Port of Churchill from about July 24 to about October 29, Type D vessels from about July 12 to about November 6 and Type C vessels from about July 5 to about November 21, with longer seasons allowable for vessels with greater ice-strengthening (Types B and A). Within the extended (July 20-November 15) season, therefore, Type E vessels would be able to operate within the above AWPPA limits, Type D vessels from July 20 to about November 6, and Types C, B and A to the limit of the new season.

In the context of this arrangement, because the vessels would be operating within the seasonal limitations specified under AWPPA regulations and for the other reasons noted above, the study team concludes that environmental risks and associated costs from the extended season as proposed would not exceed those already allowed for in the AWPPA legislation.

5. PORT SERVICES

The Port services at Churchill are provided by a number of private and public organizations with Ports Canada playing the major role. In addition to the essential services provided within the Port area and its proximity, a number of en route services are also provided by various branches of Canadian Government ministries. The principal services in this latter category are in the areas of communications and environmental information. A Coast Guard icebreaker operates in Hudson Strait during the navigation season and is available to provide assistance and advice on weather and ice conditions.

Private services include the provision of supplies. Limited supplies may be obtained locally but larger quantities must be ordered beforehand and be brought in by air or rail. Light diesel fuel oil for ships is available from the tank farm operated by Esso but heavy diesel and bunker fuel must be ordered in advance for rail delivery to the dockside. Stevedoring labour is provided from the general utility labour pool of Transport Canada and is contracted for through Wolfe Stevedors Limited based in Montreal. Fresh, potable water is available along the wharf face and is supplied to the vessels on request by Ports Canada, based on a combination of a service charge and a volume related charge.

Surface transportation is provided by VIA Rail and Canadian National Railways which operate connecting passenger and freight services to all parts of Canada. Passenger and air freight services are available at the nearby Churchill Airport. Flight frequencies to Winnipeg range from three to four turbo jet services weekly depending upon the season.

5.1 TUG ASSISTANCE

There is insufficient draft and swing room within the harbour to accommodate vessels significantly in excess of Panamax size. Waiting

vessels normally anchor outside the harbour at an exposed anchorage but light vessels exposed to strong northeast winds may be required to lift anchor and sail into the bay to ride out a storm. Vessels of approximate Panamax size and less can be accommodated within the harbour but require tug assistance to turn. Also, the larger vessels must take advantage of the additional draft resulting from tidal conditions if they are to hold full cargoes.

The primary functions of the tug service at the Port of Churchill are:

(a) to transport the port pilot between the wharf and an anchorage point in the outer harbour for both arriving and departing vessels;

(b) to assist in the docking and turning of vessels at the wharf;

(c) to assist vessels when leaving the wharf.

5.1.1 Operations

As described more fully in Chapter 3, the Port of Churchill presently owns and uses two tugs and provides the services of a pilot in order to aid and direct arriving and departing vessels. The tug "W.N. Twolan" is a twin screw single rudder vessel, powered by two 760 horsepower engines. The tug "George Kydd" is a 600 horsepower vessel. The "Kydd" is a much smaller vessel, carrying a crew of two or three and has no crew accommodation. The "Twolan", the primary vessel in service, has inadequate power to turn heavy vessels in ice and in heavy currents. As noted earlier, it is expected to be replaced by a 2,600 horsepower tug which will draw about one metre less than the "Twolan" and as a consequence can be winter berthed under all conditions of high tide. The new tug is expected to be available by July, 1986.

The pilot is generally transferred to arriving vessels at the fairway buoy, located about seven kilometres from shore. Coastal vessels, such as the NTCL tug "Keewatin", do not generally use the pilot service.

Vessels always enter the harbour on ebb tide against the current (for better steering) and berth against the dock under their own power with the bow pointing upstream. Before landing the vessels are turned on the flood tide with tug assistance.

On departure, the primary tug initiates the departure of the vessel by pulling its bow from the dock. The vessel, with the pilot on board, leaves the harbour under its own power, generally just before high tide. Once the vessel reaches the outer harbour, the pilot is transferred to the tug.

5.1.2 Constraints to Season Extension

The specifications for the new tug require that it be capable of operating in slush ice having thicknesses of up to 30 cm and in new ice with thicknesses of up to 15 cm. Under the season extension alternatives being considered, vessels may require tug assistance under ice thickness conditions of up to 40 cm (up to 30 cm by November 15). This is common practice in many Canadian ports.

The vessel handling capability of the tug in ice will have to be established under operating conditions. The evaluations in this study are based on the assumption that the new tug will be capable of providing the necessary in-harbour service until November 15th and that thereafter ice breaker assistance will be required.

5.1.3 Tug Winter Berthing

While, as noted in Chapter 3, the "George Kydd" can be lifted out for the winter season, the "Twolan" is too large and must be placed in the enclosed winter berth (east of the loading berths) a non-tidal basin isolated from tidal action by a berm of granular material filled in at the entrance to the basin after the "Twolan" has entered. Owing to its relatively deep draft the "Twolan" can navigate the shallow entrance to the basin only on high spring tides. In practice the "Twolan" has had to

enter the basin on the last spring tide in October, generally about October 15-18 (see Exhibit 3.3). Delaying until the next spring tide, four weeks later, creates the severe risk that the berm material will be frozen (so the entrance cannot be closed) and/or permanent ice will have formed (impeding or preventing the "Twolan's" movement into the winter berth.

The new tug will be able to enter the winter berth on any flood tide, thereby extending its availability in the fall until ice conditions become too severe for its operation, usually anticipated to occur on or after November 15 as noted above. In order to achieve this however, it will be necessary either to cover the berm material, protecting it from getting wet and subsequently freezing, to devise a way of thawing the berm material, to supply heavy equipment (now available to Ports Canada on a rental basis in Churchill) capable of handling the frozen material, or to replace the berm arrangement with stoplogs or a gate which can be operated late in the season.

One approach to meet season extension requirements would therefore be to provide a material storage building or cover to protect the berm materials so that they can be satisfactorily handled under freezing conditions. The estimated cost of such a structure would be between $30,000 and $50,000, depending upon the site development standards to be adopted. Alternatively, heavy equipment could be used to break up the frozen material and place it in the berm.

5.2 SHIP REPAIR

Ports Canada operates a well equipped machine shop and repair facility primarily for the maintenance of the elevator and their mobile equipment. This facility is also available for carrying out repairs to vessels using the port, and in particular, the repair of any ice damage which may occur to vessels on their inbound journeys. As noted earlier in sub-section 1.3.1, there have been a number of relatively minor incidents of this nature over the years, usually involving damage costing $2,000 to

$10,000 to repair, and for which temporary repairs were usually made in the Port.

The machine shop facility has some shortfalls in the context of ship repair operations, these being primarily a shortage of repair material inventories, particularly heavy steel plate, the lack of adequate plate cutting and bending equipment and the absence of suitably certified welders. However, some partial arrangements appear to be in place for extra labour, parts and materials to be flown in within 24 hours when required. Importantly, there are no large dry dock facilities available at Churchill, and this limits the amount of repair work that can be accomplished below the water line. It also means that loading berth space would be occupied by the vessel being repaired and would therefore not be available for active loading of grain vessels.

A number of upgrading alternatives have been considered, but the results were inconclusive, including increasing the inventory of steel plate, the provision of steel fabricating equipment and the employing of certified welders. However, there is considerable doubt as to whether vessels requiring extensive repair work would spend the time necessary to carry out permanent repairs at Churchill, or whether they would prefer to continue the present practice of carrying out only temporary repairs. In the opinion of Port management, the costs associated with the extra facilities would not likely be recovered, and there is considerable doubt that vessels would spend the time necessary for permanent repairs to be made if improved facilities were available.

It is suggested that responsibility for identifying the need for upgrading the existing repair facilities be left to the discretion of the local Ports Canada staff, based on demonstrated demand. Vessels requiring a more comprehensive service than that currently provided can be accommodated by flying in skilled personnel and materials from established shipyards in Eastern Canada, a practice similar to that currently followed by the Canadian Coast Guard, and arrangements for doing this should be formalized.

5.3 COMMUNICATIONS

Ship to shore communications are accommodated through the Canadian Coast Guard marine radio station at Churchill operating on long range frequencies. Duplex r/t service operates on the following frequencies:

- transmit - 2582 kilocycles;
- receive - 2206 kilocycles.

Additional marine radio stations are provided at Frobisher Bay and Coral Harbour, with the latter to be transferred to Frobisher Bay.

There are facilities for connecting ships directly with the commercial Manitoba Telephone System on shore. Canadian Coast Guard regulations specify the radio equipment required to be carried by Canadian and foreign vessels that trade in Canadian waters and by Canadian vessels in other waters. These regulations are described in the following publication: Radio Aids to Navigation, DP 145E, Volume 30, No. 1WE, Canadian Coast Guard, April 1, 1985. Vessels entering into Canadian waters are required to conform to these regulations.

The general procedures for the vessel entering Hudson Strait is to establish compliance through radio communication with the Port Warden's office at Frobisher Bay and then to undergo a physical inspection at the Port Warden's office following arrival at Port Churchill. The communication facilities provided for use of all navigation in the area are not specifically tailored to the requirements in the shipping sector.

At present, the coastal navigation season at the Port of Churchill opens well in advance of the proposed extended deep sea season, but the limiting requirement for maintaining facilities operational in the fall and the operating period would have to be extended to accommodate season extension at the Port. Operations in Hudson Strait, particularly

by icebreakers, normally extend to the latter part of November and early December and therefore the extended season proposed in this study will probably not require significant extensions to the current operating season of communications facilities in that area. Ice reconnaissance operations currently start in the early summer, well before the extended season proposed for deep sea navigation. Furthermore, survey activities continue through the early weeks of December when ice coverage is nearly complete. It is therefore not anticipated that additional ice reconnaissance would be required by the operation of season extension considered here, but there may be a requirement to develop more extensive information services to facilitate navigation during the extended season.

In this context, it is interesting to note the very significant advances which are being made by the Soviet Union in providing information services to mariners in Soviet Arctic waters. Information obtained from the radar carrying Soviet remote sensing Cosmos-15 satellite launched in September, 1983 has enabled scientists in the USSR to assist in the rescue of sailors trapped in ice bound vessels in the polar seas. The satellite has an orbit which passes over the polar regions and takes radar photographs of the same area once every three days. Information from the satellite and radar sensors is beamed by microwave to remote sensing receivers in Moscow, Novosibirsk and Khabarovsk. A recent practical demonstration of the system was the determination of the route which allowed 10 ships trapped in the Siberia area to escape. Earlier this year, ice information was passed on to the Mikhail Somov, a Russian vessel trapped in the ice of the Pacific sector of the Antarctic.

Japan, Canada, and the European space agency, all have indicated plans to launch a satellite in the next five years. This could be of significant benefit to shipping in the Canadian Arctic and particularly the Churchill route. Not only would better information be available, particularly during periods of overcast, but it would allow accurate forecasts to be prepared regularly on the requirements for icebreaker escort.

5.4 PILOTAGE AND PORT WARDEN SERVICES

The use of pilots by non-government vessels entering and departing the Port is mandatory during the present season. It is expected that this practice would also apply to those parts of the extended season when vessels could operate without icebreaker escort. It is, however, not clear that such services would be required when vessels are under icebreaker escort, since presumably during such periods the vessels would follow immediately behind the icebreaker on entering and departing the harbour. The operating procedures to be followed during these periods will have to be developed by the Coast Guard.

The Port Warden services in Churchill are provided during the current navigation season. These services are primarily provided to ensure that vessels conform with the Arctic Waters Pollution Prevention Act. The Port Warden ensures that cargoes on departing vessels are stowed safely from the point of view of vessel stability. During the extended season, it is possible that the Port would be not open to all vessels and navigation might be restricted only to vessels with known capability and captains with adequate experience. If this were to prove to be the case, Port Warden services in an extended season might not be an essential requirement. If required, however, the Port Warden services would simply be extended to cover the duration of the extended season.

6. PORT RECONFIGURATION

6.1 GENERAL OVERVIEW

The primary focus of the port reconfiguration was the identification of physical modifications that might be required in order to achieve the range of incremental season extensions under study. A second consideration was to determine whether the season extension objectives might not be more cost effectively achieved by relocating the Port facilities, a suggestion that has received widespread publicity.

Other factors considered were the possible requirements for improved facilities for handling additional commodities (Study B) and resupply cargoes (Study C).

6.2 BULK CARGO FACILITIES

Two of the existing three grain loading berths along the main wharf as constructed in 1929 are fitted with grain loading spouts. The conversion of these berths to bulk cargo loading or discharge berths is considered to be impractical because of the costs that would be involved in relocating the grain conveyer gallery.

The remaining free berth is used to prepare vessels for grain loading and it was in fact improved to accommodate this function. However, since vessels awaiting loading ride high in the water, a simple shallow draft open wharf could be constructed to accommodate waiting vessels, thereby freeing the grain vessel readying berth for bulk operations. The costs of these modifications, however, are independent of season extension considerations as they would be totally attributable to bulk cargo operations. Another possible solution would be to construct a new bulk cargo berth complete with commodity storage and trackage

facilities, probably to the south of the existing grain berths. This requirement also would not be a factor influencing season extension.

6.3 RESUPPLY CARGO FACILITIES

The Northern Transportation Company Limited (NTCL) resupply operations at Churchill are accommodated partly in the old transit shed located under the grain loading gallery and partly in the open area at the north end of the wharf. These facilities do not significantly interfere with grain export operations and so are not considered a factor in season extension. If the demand for resupply facilities outgrows the space available for them, a number of practical alternative solutions are possible, none of which significantly affects grain operations or season extension. These are described in Study C.

6.4 HARBOUR ICE CONTROL

A number of physical solutions to control ice formation in the harbour were examined, as described in Chapter 3. All of these appear to be most beneficial when controlling slush ice and early first year ice. They would not provide sufficient relief to significantly delay season closure, but might be considered in future to improve vessel handling and maneuverability in the area near the wharf.

As described more fully in section 3.5, a number of harbour ice control alternatives were assessed. Based on this, the recommended solutions for harbour ice control are to:

(a) Improve, if possible, the tug capability so that it can provide the assistance required to move vessels in the harbour under ice thickness of up to 30 cm (generally to mid-November).

(b) Thereafter, provide icebreaker assistance as necessary to cope with the heavier ice which progressively increases in thickness as the season advances.

The ice filter structure described in Section 3.5 is considered by the study team to be the most promising approach for ice diversion, but would cost an estimated $3.2 million, is probably not necessary for operations to November 15 because of the 1980 river diversion, and should be considered only if shown to be necessary (and cost-effective) following several years' operating experience in the extended season.

The icebreaker solution would necessitate enlarging the existing turning basin to provide adequate icebreaker maneuvering space for a season extension beyond November 15. Under this approach the existing turning basin would be widened to 365 m for the full length of the wharf at a dredged depth of 9.2 m. The cost of dredging is estimated at $3.1 million, assuming a 40 per cent factor for engineering and contingencies.

6.5 HARBOUR RELOCATION

In the past, most of the problems concerning late season navigation in Churchill stemmed from the slush ice and floating ice problem and early season ice formation within the river mouth. Since the diversion of the Churchill River, the volume of slush ice has dropped. The problems of season extension that now exists are those of floating ice and solid ice formation.

These problems are partly due to the location of the wharf facilities on the outside corner of a relatively sharp bend in the main channel of the river. Hence, ice tends to be carried to, and accumulates, on the outside radius of the river bed, which is adjacent to the south end of the wharf face. Also, significant currents are produced along the wharf face by the rising and falling tides, interfering with the turning of vessels.

An alternative way of extending the season is to avoid the ice problem associated with the river and tidal flows by totally relocating the grain loading facility.

6.5.1 Relocation Options

Option 1: Churchill River Mouth

Relocating the wharf within the basin near the river mouth would not seem to provide any significant advantage over the present location. The other possibility of moving the facility approximately one to two kilometres south of its present location and orientating the wharf north-south would result in the structure being out of the main ice flows as they currently exist. However, the required dredging for the access channel might shift the main flow of the River and cause the original ice problems to recur. Careful analysis and model studies would be required to predict the advantages of such a relocation.

Suitable and convenient access to the grain handling system is required. This would not be possible at any other location other than one upstream in the Churchill "flats" area. (Exhibit 6.1).

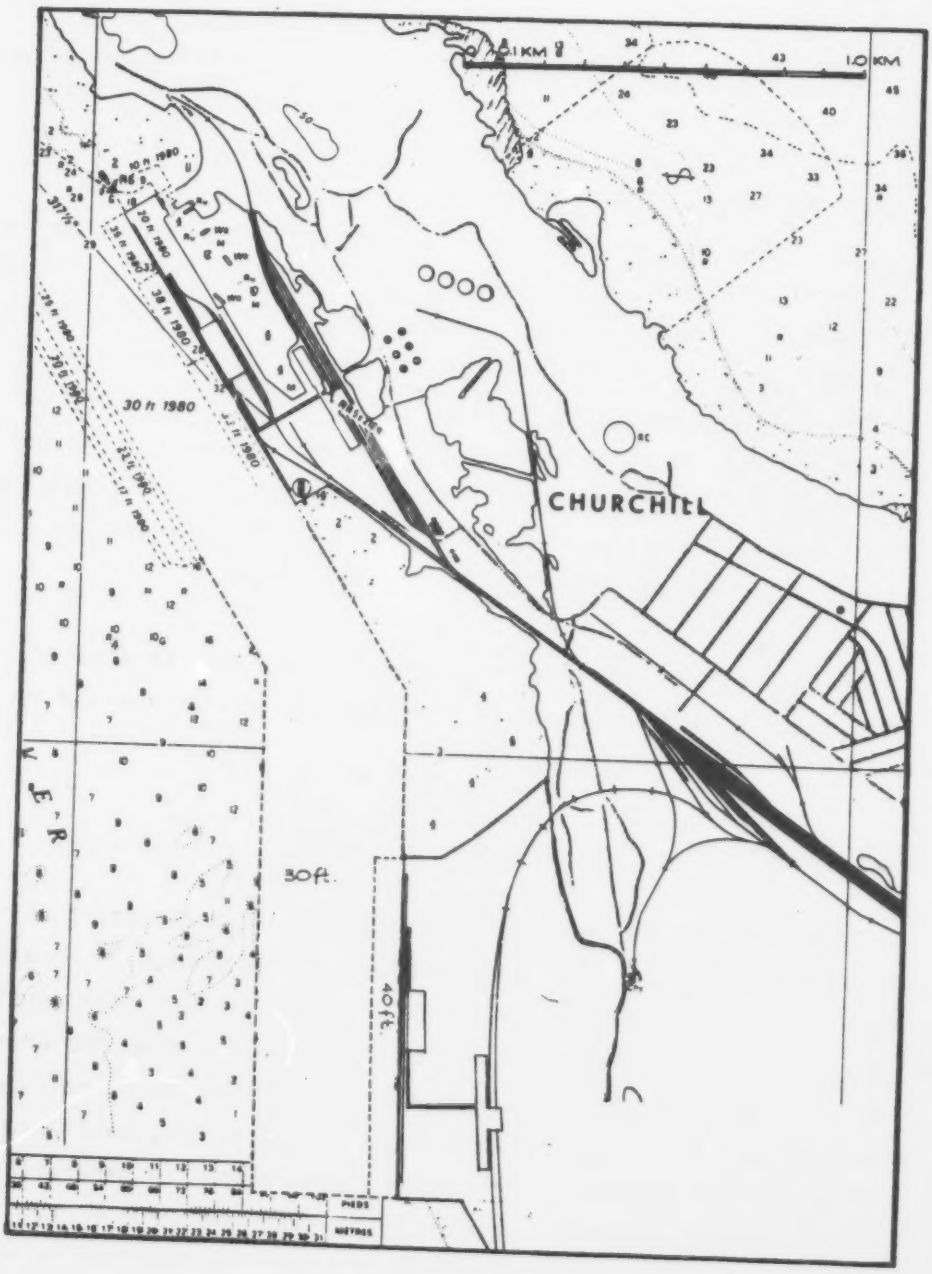
Relocating one kilometre upstream would entail dredging approximately 3,100,000 cubic metres of material at an estimated cost of $23.0 million. The estimated cost for the marine facilities, including a breasting face 850 metres long, is $32.0 million, including landfill. A new grain elevator and related facilities could cost in excess of $30.0 million or else a very complex conveying system from the old elevator would be required. Total basic capital cost would be about $85.0 million.

Option 2: Hudson Bay

The other "viable" option is to relocate the wharf and grain loading facilities outside the river mouth, in Hudson Bay. The best available location would be one directly opposite from Cape Merry. This site would allow the continued use of elevator facilities by the provision of a connecting conveyor. Unfortunately, the shore at this location is open to wave attack from the north to east direction. Owing to the size

exhibit 6.1

HARBOUR RELOCATION – OPTION 1



SOURCE STEVENSON HLUCHAN ASSOCIATES LIMITED

of Hudson Bay, very high waves are experienced. A substantial breakwater would be required, to provide both protection and accommodation for up to four grain vessels.

The proposed harbour would be formed by a substantial breakwater providing a basin approximately 500 metres wide by 600 metres long. Armour protection of the breakwater would be adequate to withstand waves up to nine metres in height. Based on the plan shown on Exhibit 6.2, the actual length of the breakwater would be approximately one kilometre, and total construction cost is estimated at $47.0 million. The harbour docking facilities would consist of a steel sheet pile pier 600 meters long, located in the middle of the basin, to allow vessels to berth on both sides costing approximately $31.0 million. The conveyor, which was not costed, would require an additional expenditure. The cost of a conveyor is highly design-sensitive in this situation and is not included because it does not affect the conclusion with respect to the two alternatives as presented in the following subsection.

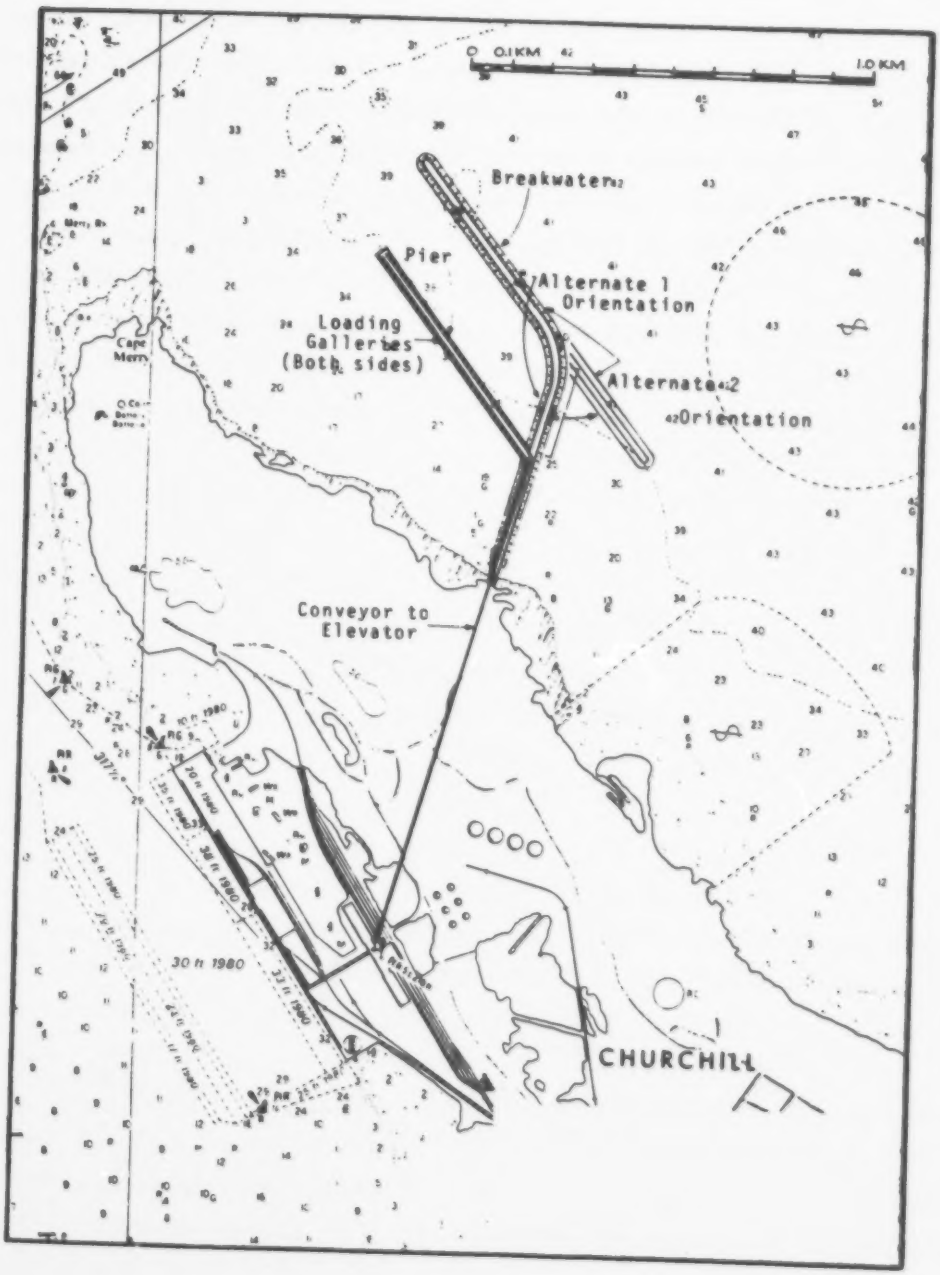
Two configurations were examined for the breakwater. The advantage of Alternate 1 is that it provides more protection and is easier to construct with shore-based equipment.

6.5.2 Evaluation

Alternate 2 is judged to be superior from the point of view of navigation and ease of ice management. The advantage of locating the facility in the bay is that ice conditions will be much more consistent. There will not be the large flows of fresh water across the wharf face which at the river mouth location alter the winter or freezing regime. Ice could be more easily cleared from the new turning basin and slips, particularly if an offshore breakwater were used. In general, the bay tends to freeze over slightly later than the existing harbour, but because of lack of ice measurement data, this cannot be analyzed to the same degree of reliability as for the existing harbour.

exhibit 6.2

HARBOUR RELOCATION - OPTION 2



SOURCE STEVENSON HLUCHAN ASSOCIATES LIMITED

Neither option appears attractive because the associated interest and annualized capital costs alone would exceed the gross operating revenues of the existing facilities at breakeven volume levels. Since the analysis shows that in future en route conditions rather than harbour icing will be the constraining factor for season extension, it would be very difficult to justify Port relocation as a means to achieve season extension, particularly as long as the existing facility has adequate capacity and can remain in operation. If, for example, the season were extended to 20 weeks and the Port were handling the maximum feasible throughput of 85,000 tonnes per week for the entire 20 week period, well over half of the gross revenue would be required to cover the amortized capital costs of the new facility, which is <u>not</u> required to achieve the season extension. A much greater net return would therefore result from proceeding with season extension using the existing Port and elevator rather than building new facilities.

7. ECONOMIC EVALUATION OF SEASON EXTENSION

This chapter presents an economic evaluation of the extension of the shipping season at the Port of Churchill. The evaluation has been prepared for three levels of grain throughput, 65,000, 75,000 and 85,000 tonnes per week which reflect the practical capability of the existing system as presently operated. The evaluation examines the cost-effectiveness of season extension at each of the three throughput levels in one week increments at both the start and end of the season.

For purposes of analysis the current season at the Port of Churchill has been defined as the 12 weeks from the 27th of July through to the 18th of October. The analysis examines the economic impact of extending the season at Churchill up to three weeks in total in advance of the current start and for a period of up to seven weeks after the 18th of October.

The analysis assumes that the Port of Churchill operates during the current season at the level of grain throughput under consideration. The analysis does not examine the question of whether or not the Port should be used during the current season. This issue is addressed in Study D.

It is also shown in Study D that the Churchill and Thunder Bay routes compete with one another, being used to move grain to many of the same destinations. Volumes of particular grain types moving through the Port of Thunder Bay generally are reduced when these same types are moving through Churchill, indicating that grain which does not move through the Port of Churchill would probably move through Thunder Bay and vice versa. Therefore, for the evaluation of season extension at the Port of Churchill we have assumed as the base case that any increase in grain shipments via Churchill would result in a corresponding decrease in grain shipments via Thunder Bay. This is a "worst case" assumption since, as pointed out in subsection 1.3.3, grain production and export projections suggest that

Thunder Bay throughputs will increase substantially by the early 1990's even if Churchill throughput levels are in the 800,000 - 1,000,000 tonnes per year range.

The evaluation of season extension is done on a weekly incremental basis where the costs of extending operations for a given week are compared with the benefits associated with that week of operation. The major cost components are the marine, Port/elevator and rail costs of grain movements via Churchill during an extended season. The costs include all additional expenditures required above those which would be spent if Churchill was in use during the current season but not during the extended season. The benefits are also those relative to no grain shipments during the extended season. These benefits include the reduction of expenditures made on grain shipments via Thunder Bay, net of reduced grain revenues at that port.

All of the dollar values in the analysis are expressed in 1985 Canadian dollars. Where appropriate, costs and benefits are expressed in dollars per tonne of grain throughput for the determination of net benefits. The net benefits for a given week of the extension period are marginal values and are therefore not additive across the different weeks of the extension period. Rather, they indicate whether or not there are positive net benefits to extending the season up to and including the given week.

The chapter is divided into five sections as follows:

- Direct Costs of Season Extension;
- Direct Benefits of Season Extension;
- Indirect Costs and Benefits and Intangibles;
- Net Benefits of Season Extension;
- Conclusions.

The first section presents the direct costs associated with an extended season. These direct costs are grouped into the following categories:

- o en route or marine;
- o harbour;
- o port and elevator;
- o railway;
- o community of Churchill.

The second section of the chapter presents the direct benefits associated with an extended season. Two types of benefits are identified, those associated with grain movement via Churchill and those associated with not moving grain via Thunder Bay. The third section of the chapter reviews the indirect costs and benefits and intangibles associated with season extension. In the fourth section of the chapter the direct and indirect costs and benefits are examined in an aggregate fashion to assess net benefits from the following five perspectives:

- o Canadian economy;.
- o Western Canadian grain producers;
- o Churchill region (that area where rail rates for grain to Churchill are lower than grain rates to Thunder Bay, Vancouver or Prince Rupert);
- o community of Churchill;
- o Port of Churchill;

Subsequently, the sensitivity of the net benefits of season extension is assessed with respect to changes in major assumptions underlying the economic assessment. For example, as explained in Chapters 1 and 2, the base case economic evaluation is for a grain throughput of

75,000 tonnes per week[1], and evaluation results are also presented for a lower throughput level of 65,000 tonnes per week and a higher level of 85,000 tonnes per week. The final section of the chapter draws overall conclusions on the economic impact of season extension.

7.1 DIRECT COSTS OF SEASON EXTENSION

The direct costs, both fixed and variable, of shipping grain via the Port of Churchill during an extended shipping season can be broken down into five components as follows:

- en route or marine costs which include the charter costs of the vessel, allowances for expected ice related vessel delay, and the costs of icebreaker and navigational services (while not borne directly by Canadians, the ocean marine freight costs are relevant because they affect the grain selling price FOB the Port);
- harbour related costs such as any marginal costs required for harbour ice control including: additional dredging, the winter berth for the tug, and icebreaker operations within the harbour;
- Port and elevator costs which include both the fixed and variable costs associated with the operation of the Port and elevator at Churchill. This includes the basic costs of operating the Port and the elevator, additional costs due to new required investments, and additional costs associated with season extension;
- railway costs from a representative point in Western Canada;
- additional community costs for infrastructure and services related to season extension.

The specific elements which make up each of these cost components are reviewed in detail in the remainder of this section.

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1. This weekly throughput level corresponds to that which would be required to achieve the Churchill throughput of 888,000 tonnes projected for 1990 by the Canada Grains Council in the normal 12 week shipping season.

7.1.1 En Route Marine Costs

The costs associated with the en route or marine portion of grain movement via the Port of Churchill include the following elements:

- o basic vessel costs and rates;
- o costs of ice related delay en route;
- o incremental cost of icebreaker escort services;
- o incremental cost of navigational services.

Basic Vessel Costs and Rates

Based on the analysis undertaken for Study D, Port of Churchill Grain Shipping Costs, with respect to the capital and operating costs of bulk carriers travelling between Rotterdam (selected as a typical destination port in Western Europe) and the Port of Churchill, the long term average costs of the vessel are as follows:

Long Term Average Costs of a
25,000 D.W.T. Bulker (Non Ice-Strengthened)

Item	Unit Cost	No. of Units	Voyage Cost
Costs En Route	$16,140/day	22	$355,100
Costs in Port	10,210/day	7.2	73,500
Cost of Loading	25,000	-	25,000
Cost of Unloading	15,000	-	15,000
Total Voyage Costs			$468,600

The actual rates charged for grain shipments between the Port of Churchill and Rotterdam may be higher or lower than this long term average cost depending upon ocean freight market conditions. An analysis of ocean

freight rates undertaken in Study D estimated the rate charged for grain movements from Churchill to Rotterdam under three market conditions: low, medium and high. These rates are presented below:

Marine Freight Rates
Churchill - Western Europe

Scenario	Rate ($ Cdn/tonne)
Low Market (1985)	$15.30
Medium Market (1981)	$23.20
High market (1980)	$39.40

In this chapter, medium market rates are used as the base condition for the economic assessment of season extension. Long term average costs are used to estimate the potential impact on rates of vessel delay due to ice conditions. Sensitivity analysis is performed later in this chapter to assess the impact of the low and high market rates on the economics of season extension.

The above basic rates reflect the rates experienced during the current shipping season by a mix of APPWA Class E and Class D vessels. Outside of the calendar limits set for Class E vessels by AWPPA for travel to and from Churchill, the basic rate is adjusted to cover the additional costs of using solely ice-strengthened vessels. These additional costs have been estimated to be $20,000 per voyage or $0.80/tonne, based on 15 percent higher capital costs for ice-strengthened vessels.

Costs of Ice Related Delay En Route

Season extension will result in additional marine shipping costs associated with delays due to ice conditions en route between Cape Chidley and the Port of Churchill. These incremental costs include two elements:

- the estimated cost of ice related vessel delay en route when the ice is not under pressure conditions and the vessel can proceed through the ice pack at lower than usual speeds;

- the estimated cost of vessel delay when the ice is under pressure conditions. In these situations, a vessel would typically wait outside of the area experiencing pressure ice conditions until these conditions improve.

Estimates were made of the expected sailing times between Cape Chidley and the Port of Churchill based on actual ice conditions recorded during the years 1959 through 1983. These estimates do not include the impacts of pressure ice conditions which are treated separately on the next page. The estimated sailing times are tabulated in Appendix A. Based on the expected sailing times, expected hours of delay were calculated for the following three scenarios:

- good ice years which occur on average once every five years and result in low levels of ice coverage;

- moderate ice years which occur on average three out of five years and represent typical ice coverage conditions;

- heavy ice years which occur on average once every five years and represent the worst ice conditions en route.

Exhibit 7.1 presents the total expected cost of delay to commercial vessels due to navigation through ice and pressure ice conditions. The supporting calculations for these estimates are presented in Chapter 4 and Appendix A. These costs are presented in dollars per tonne for years with good, moderate and heavy ice conditions by week for the period July 6th through December 6th outside the existing season. The specific elements of Exhibit 7.1 and their definitions are given below:

- base sailing time - this is the time required to sail from Cape Chidley to Churchill at an average speed of 13 knots over the likely route to be used during any given week;

exhibit 7.1

COST OF BASIC DELAY DUE TO ICE COVERAGE TO COMMERCIAL VESSELS

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
BASE SAILING TIME(HRS)	88.5	88.5	88.5	82.3	82.3	82.3	82.3	82.3	84.6	84.6
EXPECTED SAILING TIME										
GOOD YEARS	97.1	90.5	88.8	82.3	82.3	82.3	82.4	83.0	86.6	102.6
MODERATE	122.6	101.1	93.2	82.3	82.4	82.6	85.3	92.6	111.5	159.3
HEAVY ICE	181.1	133.8	106.1	84.6	86.6	94.1	111.1	139.3	181.3	222.0
HOURS OF DELAY DUE TO ROUTING	12.4	12.4	12.4	0.0	0.0	0.0	0.0	0.0	2.3	4.6
HOURS OF DELAY PER VESSEL DUE TO ICE COVERAGE										
GOOD YEARS	10.5	2.3	0.3	0.0	0.0	0.0	0.1	0.8	2.7	20.0
MODERATE	46.7	17.3	6.0	0.0	0.1	0.4	3.3	13.3	37.2	101.6
HEAVY ICE	137.9	62.9	27.2	3.3	6.6	16.1	40.6	85.8	153.6	234.0
COST OF DELAY PER VESSEL ($)										
GOOD YEARS	15,350	9,830	8,510	0	0	0	40	520	3,360	16,500
MODERATE	39,620	19,880	12,340	10	60	240	2,180	8,900	26,470	71,150
HEAVY ICE	100,720	50,440	26,510	2,200	4,420	10,770	27,180	57,500	104,490	159,900
COST OF DELAY ($/TONNE)										
GOOD YEARS	0.61	0.39	0.34	0.00	0.00	0.00	0.00	0.02	0.13	0.66
MODERATE	1.58	0.80	0.49	0.00	0.00	0.01	0.09	0.36	1.06	2.85
HEAVY ICE	4.03	2.02	1.06	0.09	0.18	0.43	1.09	2.30	4.18	6.40
EXPECTED COST OF WAITING DUE TO PRESSURE ICE CONDITIONS										
HOURS OF WAITING PER VESSEL										
GOOD YEARS	0	0	0	0	0	0	0	0	0	0
MODERATE	30	6	0	0	0	0	0	0	12	60
HEAVY ICE	96	42	18	0	0	0	6	48	108	168
COST OF WAITING PER VESSEL ($)										
GOOD YEARS	0	0	0	0	0	0	0	0	0	0
MODERATE	12,900	2,600	0	0	0	0	0	0	5,200	25,800
HEAVY ICE	41,300	18,100	7,700	0	0	0	2,600	20,600	46,400	72,200
COST OF WAITING ($/TONNE)										
GOOD YEARS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MODERATE	0.52	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.21	1.03
HEAVY ICE	1.65	0.72	0.31	0.00	0.00	0.00	0.10	0.82	1.86	2.89
TOTAL EXPECTED ADDITIONAL COST TO COMMERCIAL VESSELS DUE TO ICE CONDITIONS										
COST OF DELAY AND WAITING ($/TONNE)										
GOOD YEARS	$0.61	$0.39	$0.34	$0.00	$0.00	$0.00	$0.00	$0.02	$0.13	$0.66
MODERATE	2.10	0.90	0.49	0.00	0.00	0.01	0.09	0.36	1.27	3.88
HEAVY ICE	5.68	2.74	1.37	0.09	0.18	0.43	1.19	3.12	6.04	9.28

- expected sailing time - this is the expected time required to sail from Cape Chidley to Churchill when delays due to ice coverage are taken into account;

- hours of delay per vessel due to routing - this value represents that additional time spent en route by the vessel both inbound and outbound due to longer routings required at the beginning and end of the season. At the beginning of the season, it is assumed that the vessel sails inbound during the week being tabulated and outbound during the following week. This assumption is reversed at the end of the season;

- hours of delay per vessel due to ice conditions - this value represents the difference between expected sailing time and base sailing time for both the inbound and outbound directions;

- cost of delay per vessel - this value is equal to the hours of delay multiplied by the hourly cost assuming a vessel cost of $16,140 per day. It is assumed that fuel consumption would not be reduced significantly at lower sailing speeds due to the additional power required to sail through or maneuver around ice flows;

- cost of delay per vessel ($/tonne) - this value is the cost of delay for the vessel divided by the dead weight tonnage of the vessel;

- hours of waiting per vessel due to pressure ice - this value represents the additional delay expected due to pressure ice conditions. Based on discussions with Captain Pelletier, it has been assumed that for every 12 hour period during which icebreaker escort is required, there is a 50 percent chance of a 12 hour delay due to pressure ice conditions;

- cost of waiting per vessel - this value is determined by multiplying the expected hours of delay due to pressure ice by the equivalent cost of $10,210 per day, the cost of the vessel excluding marine fuel;

- cost of waiting per vessel ($/tonne) - this value is calculated by dividing the cost per vessel due to pressure ice conditions by the dead weight tonnage of the vessel;

- total cost of delay per vessel ($/tonne) - this value is the sum of the cost per tonne of delay due to ice coverage and the cost per tonne due to pressure ice conditions.

As shown in the exhibit, the total cost of delay is expected to remain relatively low except during heavy ice years both early and late in the study period, and during moderate ice years for both the first and last weeks in the study period. Costs due to delay during extended weeks of operation remain below $.50/tonne from the 20th of July until the 22nd of November in all but heavy ice years.

Incremental Cost of Icebreaker Escort Services

As indicated in Chapter 4, the salaries and wages of officers and crew on-board the icebreakers which serve in Hudson Bay and Hudson Strait are already covered by the annual budgets of the Coast Guard. Furthermore, since extended operations in Hudson Bay and Hudson Strait would not involve any change in the icebreaker fleet size or any additional sailing requirements to reach the area, there would be no additional capital costs or incremental operating costs incurred for the standby service en route to Churchill. Therefore, the principal incremental costs for icebreaker services in the Hudson Bay and Hudson Strait areas at the beginning and end of the shipping season from Cape Chidley to the Port of Churchill are additional fuel costs and crew overtime costs.

Exhibit 7.2 presents the incremental icebreaker costs expected during good, moderate and heavy ice years by week for the period July 6th through December 6th outside the existing season. Again, the basis for these estimates is presented in Chapter 4 and Appendix A. The specific elements of Exhibit 7.2 and their definitions are given below:

- escort hours (one-way) spent icebreaking per vessel - this is the time spent icebreaking for commercial vessels sailing between Cape Chidley and the Port of Churchill. Since in a given season areas of significant ice coverage tend to be concentrated within particular sections of the route between Cape Chidley and Churchill, and since vessels will be travelling in both directions along the route, the escort hours have not been increased to account for possible "deadheading" of the icebreakers;

exhibit 7.2

INCREMENTAL COST OF ICEBREAKER ESCORT SERVICES EN ROUTE

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
COSTS DUE TO ICE COVERAGE										
ESCORT HOURS (ONE-WAY) PER VESSEL SPENT ICEBREAKING										
GOOD YEARS	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3
MODERATE	55.2	17.6	4.9	0.0	0.0	0.0	0.3	4.3	26.7	105.4
HEAVY ICE	138.3	68.7	28.1	2.3	1.3	9.3	22.0	85.4	142.9	210.0
ICEBREAKER FUEL & OVERTIME COSTS PER VESSEL (TWO-WAY TRIP)										
GOOD YEARS	5,200	0	0	0	0	0	0	0	0	5,400
MODERATE	47,400	14,700	4,200	0	0	0	200	3,000	20,100	85,900
HEAVY ICE	134,600	62,900	29,400	1,500	2,400	6,900	20,400	69,800	148,400	229,400
FUEL & OVERTIME COSTS ($/TONNE)										
GOOD YEARS	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
MODERATE	1.90	0.59	0.17	0.00	0.00	0.00	0.01	0.12	0.80	3.44
HEAVY ICE	5.38	2.52	1.18	0.06	0.10	0.28	0.82	2.79	5.94	9.18
ICEBREAKER COSTS DUE TO PRESSURE ICE CONDITIONS										
HOURS SPENT WAITING (ONE-WAY) PER VESSEL DUE TO PRESSURE ICE CONDITIONS										
GOOD YEARS	0	0	0	0	0	0	0	0	0	0
MODERATE	30	6	0	0	0	0	0	0	12	60
HEAVY ICE	96	42	18	0	0	0	6	48	108	168
ADDITIONAL ICEBREAKER OVERTIME COSTS PER VESSEL (TWO-WAY TRIP)										
GOOD YEARS	0	0	0	0	0	0	0	0	0	0
MODERATE	5,400	900	0	0	0	0	0	0	1,800	10,800
HEAVY ICE	20,700	9,000	3,600	0	0	0	900	8,100	23,400	41,400
ADDITIONAL ICEBREAKER FUEL & OVERTIME COSTS ($/TONNE)										
GOOD YEARS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MODERATE	0.22	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.43
HEAVY ICE	0.83	0.36	0.14	0.00	0.00	0.00	0.04	0.32	0.94	1.66
TOTAL INCREMENTAL ICEBREAKER COSTS DUE TO ICE CONDITIONS										
GOOD YEARS	$0.21	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.22
MODERATE	2.11	0.62	0.17	0.00	0.00	0.00	0.01	0.12	0.88	3.87
HEAVY ICE	6.21	2.88	1.32	0.06	0.10	0.28	0.85	3.12	6.87	10.83

- o icebreaker fuel and overtime costs per vessel - this value is determined by multiplying total inbound and outbound escort hours by $500 per hour to cover additional fuel costs and $150 per hour to cover additional overtime costs. (Overtime costs of $25,000 would be incurred for each weekend worked; however, in the study this cost has been prorated over the entire week);

- o icebreaker fuel and overtime costs ($/tonne) - this value represents the incremental icebreaker costs per vessel round trip due to ice coverage divided by the dead weight tonnage of the vessel being escorted (the vessel is assumed to have a D.W.T. of 25,000 tonnes);

- o hours spent waiting (one-way) per vessel due to pressure ice conditions - this value is determined using the same approach as for the commercial vessel being escorted;

- o icebreaker overtime costs per vessel (round trip) - this value is determined by multiplying the expected hours spent waiting for both the inbound and outbound portions of the voyage by the prorated overtime costs of $150 per hour;

- o additional icebreaker overtime costs ($/tonne) - this value is the additional overtime cost divided by the dead weight tonnage of the vessel being escorted;

- o total incremental cost of icebreaker services en route ($/tonne) - this value is the sum of the incremental icebreaker costs due to ice coverage and the incremental costs due to pressure ice conditions.

As indicated in the exhibit, the total incremental cost for icebreaker services remains relatively low except in situations of heavy ice coverage and the first and last weeks under review.

Incremental Cost of Navigational Services/Telecommunications

Currently the Canadian Coast Guard operates radio stations at Churchill, Coral Harbour and Frobisher Bay along the route between the Port of Churchill and Cape Chidley. These stations are in operation from

the beginning of June until mid-October when the last grain vessel has left the area. There are plans to close the station at Coral Harbour and shift those services to Frobisher Bay. Therefore, an extension of the season at Churchill will require the maintenance of operations of the radio stations only at Churchill and Frobisher Bay. The Coast Guard estimates that the marginal cost of operations of these services are $5,000 and $15,000 per week respectively. These costs would be incurred for every week of extension beyond the current end of the season.

7.1.2 Incremental Harbour Costs

In this section, the incremental costs for improvements to or services for the Churchill harbour are presented. The improvements and services include:

- improvements to the winter berth for the larger of the two tugs operating in the port;
- land based navigational aids;
- additional dredging of the harbour;
- icebreaker services within the harbour.

Cost estimates for these improvements are based in part on information drawn from Chapter 3.

Improvements to Winter Berth

As indicated in Chapter 3, the physical closing of the winter berth for either the tug "Twolan" or the new tug when it is commissioned represents an actual or potential constraint to season extension. This constraint can be overcome by either covering the berm material used to close off the winter berth during the summer season or storing the material in a storage building to prevent moisture from collecting, using heavy equipment capable of handling frozen material from the stockpile, using heavy equipment capable of handling frozen material from the stockpile, or constructing a stop-log type gate to replace the temporary

berm. It is estimated that the cost of an appropriate solution to the problem (a storage building or cover) would be in the order of $50,000 with an expected life of 20 years. If this cost is amortized at an interest rate of 11 percent, the annual cost would be approximately $6,300. The interest rate was selected to be consistent with the analyses in Study D. The alternative of using heavy equipment to construct the berm would have an estimated annual cost of about the same amount. This expenditure would not be required until the week ending November 8th. This cost is assumed to be fixed regardless of the volume of grain movement through the Port and the length of the season extension beyond November 8th.

Since the economic analysis of season extension is being performed on a weekly incremental basis, the cost for any given week after this improvement is required is equal to $6,300 divided by the number of weeks from when the improvement was initially required. It should be noted that as a result of this approach, weekly costs are not additive across time; rather, the total costs for any given week can be compared to the total benefits for that same week in order to determine the point at which season extension is no longer economically viable.

The table below presents the allocated cost improvements to the winter berth for weeks ending November 8th through December 6th.

	Week Ending				
	08-Nov (1 week)	15-Nov (2 weeks)	22-Nov (3 weeks)	29-Nov (4 weeks)	06-Dec (5 weeks)
Allocated Cost of Winter Berth Improvements (Weekly)	$ 6,300	$ 3,150	$ 2,100	$ 1,575	$ 1,260

Navigational Aids

Both floating buoys and land based ranges are used as navigaticnal aids (channel markers) within the harbour to identify the limits of

the shipping channel and turning basin. Since the harbour is free of ice well before the shipping season to Churchill begins, there is no problem in placing the buoys a few weeks before the current start of the season. At the end of the season, the buoys become unreliable due to their movement by ice within the harbour. After this time, the pilot relies solely on the land based ranges. The ranges include a beacon on the elevator for long distance orientation and three pairs of range lights to mark the channel and turning basin.

These ranges have been sufficient in the past for the few vessel movements which occur after the removal of the buoys. In the future, if there is extensive use of the harbour after mid-October, the Coast Guard indicated that it may be appropriate to install two radar transponders (Racons) at a cost of $40,000 each. This investment would be needed only if experience showed that the existing land ranges were insufficient, and is not included in the estimated costs for season extension.

Additional Dredging for Icebreaker Operations

As indicated in Chapter 3, an icebreaker would be required to maintain a clear channel between the harbour and Hudson Bay, to break ice within the turning basin in the harbour, and to break ice near the dock after November 15th. In order to accommodate icebreaking and vessel turning after November 15th, the turning area opposite the berths should be widened from 300 metres to 365 metres to a 9.2 metre depth below datum. The initial cost of this additional dredging is estimated to be $3.1 million with additional annual costs of $10,000 to maintain the newly dredged area. The maintenance costs in the extended turning basin would be incremental to the cost of the main dredging program in the harbour. The 1985 soundings show very little if any sedimentation in the area of the proposed extended turning basin, whereas the berths along the wharf have experienced significant sedimentation (compare Exhibits C-1 and C-2 showing 1980 and 1985 soundings respectively). The $10,000 annual dredging cost figure, when accumulated over the periods between major

dredgings, is proposed as a contingency allowance to pay for the incremental costs of correcting any minor sedimentation or bottom shifts which may occur in the extended basin area.

If the dredging cost is amortized over 30 years at a rate of 11 percent, the annualized value of the capital cost is $357,000. Therefore, a total annual cost of $367,000 would be incurred in order to allow the harbour to be used after November 15th. Since this additional dredging is generally required only for operations after November 15th, the cost must be allocated to shipments during the weeks following November 15th. As before, the average costs are calculated on an incremental basis by week. The estimates of the allocated weekly costs of the additional dredging are presented in the table following for the period during which icebreaker operations would be necessary in the Port:

	Week Ending				
	08-Nov	15-Nov	22-Nov (1 week)	29-Nov (2 weeks)	06-Dec (3 weeks)
Allocated Additional Annual Dredging Costs (Weekly)	-	-	$367,000	$183,500	$122,300

The allocated weekly cost of the additional dredging required to accommodate icebreaker operations is significant, particularly if the season is extended only to the week ending November 22nd (one week only of icebreaker operations).

Incremental Icebreaker Costs - Harbour Operations

The increasing accumulation of ice within the harbour after the week ending the 15th of November would result in the requirement for icebreaking operations on a daily basis. As indicated earlier, the incremental costs of icebreaker operations in Hudson Bay consist of additional fuel costs and costs associated with working operations on weekends. The table below presents estimated hours of operations by week

at the end of the season, and the weekly incremental costs of these operations. These estimates are based on the study team's assessment of the potential level of effort required to undertake this task.

	Week Ending				
	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
Hours of Icebreaker Operations Per Week	-	-	30	60	70
Additional Fuel Costs	-	-	$ 15,000	$ 30,000	$ 35,000
Overtime Costs	-	-	-	$ 12,000	$ 24,000
Total Costs Per Week	-	-	$ 15,000	$ 42,000	$ 59,000

The use of icebreakers to turn vessels in the harbour may result in additional risks to the Coast Guard. This additional risk primarily relates to the assisting of vessels at the wharf. This function is similar to the one already performed by the Ports Canada tugs.[2] Since both Ports Canada and the Coast Guard are self-insured by the Government of Canada, the proposed application would involve a transfer of risk from Ports Canada to the Coast Guard and therefore does not constitute an additional cost.

7.1.3 Port and Elevator Costs

Data on the annual expenses and revenues for the Port of Churchill were obtained for the years 1970 through 1984. In addition, some preliminary financial data for 1985 were also obtained. This detailed financial information was aggregated into four main categories for the most recent ten years (1975 through 1984). The four categories are:

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2 There is no history of significant accidents resulting from the turning or towing of vessels at the wharf by Ports Canada.

- o labour;
- o purchases;
- o development and miscellaneous;
- o indirect costs.

The actual values for each of the individual cost items in these categories were adjusted to 1985 dollars based on the Consumer Price Index (CPI). Other indices, including the construction and manufacturing labour cost indices, were examined. The adjusted values using these other indices were not significantly different from those obtained using the CPI; therefore, the CPI was used throughout to convert all costs to 1985 dollars. The adjusted costs for each of the cost categories for the years 1975 through 1984 are presented in Exhibit 7.3. The exhibit also presents the grain throughput which occurred in each year (not including screenings/pellets). In the remainder of this section a cost model for the elevator is developed based on the relationship between historical costs and grain throughput.

Labour Costs

Labour costs are subdivided into four components: regular, overtime, outside and fringe benefits. A graph of all of these components versus grain throughput was examined, and on the basis of the trends exhibited in the graph, regression lines were fitted to the regular and overtime values for the years 1976 through 1984. The regression line indicates that regular and overtime costs account for an annual fixed cost of $1,663,000 and a variable cost of $1.71 per tonne of grain. Outside labour costs are statistically independent of throughput. These costs are estimated to be an average fixed annual amount of $5,700, which represents the average of 1976 through 1984 values. Fringe benefits to the staff were estimated to be 15 percent[3] of both the fixed and variable components of the regular and overtime costs.

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3 In practice, this ranges from 13 to 18 percent at Churchill.

exhibit 7.3

HISTORICAL COSTS OF THE PORT OF CHURCHILL EXPRESSED IN 1985 CANADIAN DOLLARS

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
GRAIN THROUGHPUT	494,456	694,767	729,183	519,389	522,565	289,485	438,390	356,456	621,205	437,148
1985 $ COSTS										
LABOR REGULAR	2,301.3	2,282.6	2,167.0	2,151.8	2,103.4	1,876.5	1,946.0	2,138.1	2,171.2	1,976.9
OVERTIME	588.9	707.1	717.1	480.3	566.4	250.4	402.7	548.9	658.0	255.0
OUTSIDE	0.0	0.8	0.0	0.0	1.1	20.8	2.3	15.3	10.6	0.6
BENEFITS	318.2	401.5	370.4	312.4	317.0	382.6	238.6	427.3	505.1	295.3
TOTAL LABOR	3,208.5	3,392.0	3,254.5	2,944.5	2,987.9	2,450.4	2,589.5	3,129.7	3,344.9	2,527.8
PURCHASES										
PROFESS. & FEES	1,095.2	911.3	1,094.6	848.3	801.3	817.1	988.4	1,043.9	568.8	411.3
REPAIRS & MAINT.	68.8	20.2	10.7	34.7	32.2	25.0	376.6	68.1	28.7	414.0
MATERIALS	590.2	298.0	178.3	314.4	231.0	321.5	379.4	429.3	483.7	405.8
ENERGY	384.4	776.3	774.7	782.5	797.6	887.6	1,002.8	887.8	1,013.5	859.2
OTHER	80.7	64.8	61.1	41.7	50.6	55.4	45.7	52.6	66.3	73.2
TOTAL PURCHASES	2,219.3	2,070.5	2,119.4	2,021.6	1,912.8	2,106.5	2,792.9	2,481.8	2,160.9	2,163.5
DEVELOPMENT & MISC.										
DEVELOPMENT	166.8	65.0	49.5	36.6	48.1	58.5	66.7	56.8	71.7	54.5
MISCELLANEOUS	109.3	203.2	58.3	82.9	87.9	31.5	34.0	55.1	63.9	41.5
TOTAL DEV. & MISC.	276.1	268.1	107.8	119.5	136.0	90.1	100.8	111.9	135.6	96.0
TOTAL DIRECT OPERATING	5,704.0	5,730.7	5,481.7	5,085.6	5,036.7	4,646.9	5,483.2	5,723.3	5,641.3	4,787.3
INDIRECT COSTS										
DEPRECIATION	753.8	1,058.2	1,340.8	1,090.8	1,086.1	1,297.1	1,394.8	1,339.8	1,170.6	1,107.7
RIGHTS	786.6	703.9	683.1	740.6	713.4	668.3	666.6	621.3	646.3	633.3
OVERHEAD	326.0	227.6	199.4	179.6	190.4	205.1	250.6	314.3	466.3	273.7
TOTAL INDIRECT COSTS	1,866.4	1,989.6	2,223.3	2,011.0	1,990.0	2,170.6	2,312.0	2,275.4	2,283.1	2,014.6
TOTAL COSTS	7,570.4	7,720.3	7,705.0	7,096.6	7,026.7	6,817.5	7,795.2	7,998.7	7,924.5	6,802.0

Based on past performance, the total annual labour costs for the port and elevator given a 12 week shipping season are estimated to be $1,918,000 plus $1.97 per tonne of grain throughput.

The extension of the shipping season will result in a marginal increase to the fixed component of the labour costs in addition to the variable cost of $1.97 per tonne of grain. Based on a review of the distribution of labour costs in 1984 between seasonal and full time employees and elevator and administrative employees, it is estimated that the additional weekly fixed costs would be $29,900 consisting of $26,000 in regular wages and $3,900 in benefits.

Purchases

The cost elements included in the purchases category are as follows:

- outside professional fees and special services;
- purchased repairs and maintenance;
- materials, supplies and small tools;
- energy costs including fuel, gas, oil, electricity and water;
- other purchases including communications and transport, and office expenses.

Port of Churchill accounting staff estimated that, of the five elements, only materials and energy would vary by the volume of throughput during the current shipping season. The other elements were treated as fixed annual costs. The estimated values for each of the components were calculated as follows[4]:

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4 Different timeframes have been used as appropriate to reflect changes in trends in volume related costs.

- outside professional fees and special services - this value was taken to be the average of the 1983 through 1985 costs in 1985 dollars. The values previous to 1983 were not considered since they included a flow through expense of the Canadian Grain Commission. The estimated value for this element is $453,400;

- repairs and maintenance - this element was set equal to the average expenditures from 1976 through 1984 in 1985 dollars or, $112,200;

- materials - a review of this cost element versus grain throughput indicated that there was a consistent relationship between the cost of this element in 1985 dollars and grain throughput for the years 1980 through 1984. A regression line was fitted through these points yielding a fixed component of $194,100 and a variable component of $0.45 per tonne;

- energy - the relationship between energy costs in 1985 dollars and grain throughput was also reviewed. For this cost element, 1985 values were available and there appeared to be a consistent relationship between grain throughput and costs in 1985 dollars for the years 1982 through 1985. A regression line was fitted to these values yielding a fixed component of $651,000 and a variable component of $0.51 per tonne;

- other - this cost element was set equal to the average expenditure from 1976 through 1984 in 1985 dollars. The estimated value of this element is $56,800.

Based on discussions with Port accounting staff, it has been estimated that during an extended season there would be no increase in overall expenditures on outside professional fees and special services, purchased repairs and maintenance and "other" purchases. It should be noted that there will likely be repair and maintenance work performed during any season extension; however, the cost of this work is covered by the variable labour cost. It is further estimated that expenditures on materials will continue during an extended season at the variable cost rate of $0.45 per tonne.

Additional energy costs would also be incurred during an extended season. Based on a review of energy and water consumption data from 1984, it is estimated that additional fixed costs of $7,000 per week would be

incurred. The variable cost of $0.51 per tonne would also be incurred assuming that Hydro rates for the additional power consumption remain unchanged.

With the construction of the hydro electric dam near Gillam, Manitoba and the subsequent supply of hydro electric power to Churchill, the rates paid for power may drop significantly. It is understood that any decrease in rates would apply only to new power consumption for federal government power users such as the Port of Churchill. Currently, the Port of Churchill pays $0.20 per kWh, whereas the proposed new rate would be in the order of $0.08 per kWh. If the additional power consumed during a season extension were subject to this lower rate the variable costs would drop to $.20 per tonne. The impact of this rate change is assessed in the sensitivity analysis section of this chapter. For the base case economic evaluation, the existing electricity rate of $0.20 per kWh is used. This is equivalent to $0.51 per tonne at all levels of grain throughput.

Development and Miscellaneous Expenses

This cost category includes such components as advertising, contributions, grants and memberships, travel and entertainment, and miscellaneous expenses. Based on a review of the relationship between grain throughput and the values of these expenses in 1985 dollars, development expenses were estimated to be a fixed cost of $61,700, the average cost in 1985 dollars from 1976 through 1984. Miscellaneous expenses exhibited a close relationship to grain throughput for the years 1980 through 1984; therefore, a regression line was fitted to these data with a resulting fixed component of zero and a variable component of $0.10 per tonne.

During an extended season it was estimated that the miscellaneous costs would continue at $0.10 per tonne and that there would be no additional development expenses.

Total Direct Operating Costs

As indicated in Exhibit 7.4, the estimated total direct operating costs incurred on an annual basis assuming a 12 week shipping season are $3.45 million plus $3.04 per tonne of grain throughput. Extension of the shipping season by weekly increments is expected to add $29,900 per week in fixed labour costs and $7,000 per week in fixed purchase costs for a total of $36,900 per week in fixed costs and $3.04 per tonne in variable costs. The costing of the season extension is valid only for grain throughputs of 40,000 tonnes per week or more since below this volume the relationship between cost and throughput may not be linear.

Indirect Port and Elevator Costs

The specific components that are included in the indirect costs for the Port are: depreciation, grants in lieu of taxes and national office allocation of overhead. The first of these is a function of the asset base of the Port, the second is a function of the assessed value of the Port, while the third is a function of the head office costs of Ports Canada. All three of these elements are independent of the grain throughput at the Port of Churchill. The 1984 values of these elements in 1985 dollars are estimated to be indicative of the appropriate level for these costs. These costs are also independent of the duration of the shipping season and therefore there are no marginal indirect Port and elevator costs associated with season extension. The estimated values of these costs are presented in Exhibit 7.4 and are $1.11 million for depreciation, $0.63 million from grants in lieu of taxes, and $0.27 million for national overhead..

Total Existing Port Costs

As indicated in Exhibit 7.4 the estimated total annual costs of the Port of Churchill, assuming a 12 week shipping season, are $5.46 million plus $3.04 per tonne. Additional fixed costs of $36,900 per week

are incurred for each week the shipping season is extended. In addition, the variable costs of $3.04 per tonne are also incurred.

The above total costs cover all of the services provided by the port including those to NTCL and other non-grain port users. If it is assumed that the revenues of approximately $580,000 received from NTCL and others in 1984 are indicative of the costs incurred for the provision of services to these companies, the grain related fixed costs of the Port for a 12 week season are $4.88 million. There would be no change in the variable cost component or in the additional costs which would be incurred as a result of an extension to the shipping season to adjust for NTCL usage of the Port.

Dust Control Equipment

In order to meet regulations covering work conditions, the Port of Churchill will need to install dust control equipment. As indicated in Study D, the annualized cost of this equipment is estimated to be $575,000. This cost is not reflected in the historical data on Port operating costs and therefore must be added to the fixed costs incurred every shipping season at the Port. This cost should be (and is in our analysis) fully allocated to the current shipping season since it is required whether or not the season is extended.

Port Dredging

The $6.6 million dredging project by Ports Canada is believed to be committed. This program has been justified as the basis of the existing season. The additional benefits of this project which may accrue during season extension have not been considered.

Canadian Grain Commission

As reported in Study D, the Canadian Grain Commission incurs excess costs of $50,000 per season in the provision of inspection services at the Port of Churchill. These excess costs are not expected to vary significantly with season extension. Therefore, this cost should be (and is in our analysis) fully allocated to the current shipping season.

7.1.4 Railway Costs

The railway costs associated with grain shipments via the Port of Churchill include the following three components:

- volume related rail costs as reflected in the rail rate;
- additional line related costs (as specified by CN and identified in Study D);
- additional rail car related costs.

The basic railway rate for grain shipments to the Port of Churchill from Western Canada is distance related. Analysis undertaken as part of Study D indicates Saskatoon is a representative location in Western Canada for the comparative analysis of grain movements via Churchill versus via Thunder Bay, since its rail rate advanatage is very close to the weighted average rail rate advantage for all grain moving through Churchill.

The rate for grain shipments from Saskatoon to the Port of Churchill is $26.65 per tonne. It is assumed that this rate can be used as a proxy for all railway costs associated with grain shipment from Saskatoon to Churchill except for the additional costs specified below. Furthermore, as described in Chapter 2 it is estimated that these per tonne costs would not change significantly during an extended season.

Line Related Costs

Analysis undertaken in Study D indicates that the operation of the railway line from Thompson Junction to the Port of Churchill results in line related costs of $4.62 million. These costs would be saved only if the line from Thompson Junction to the Port of Churchill were closed. Therefore, this cost is not included in the basic economic assessment of season extension at the Port of Churchill. Furthermore, this cost, if included, should be fully allocated to the existing season; therefore, the marginal cost of this item for season extension is nil.

Rail Car Related Costs

Boxcars are currently used for grain shipments to the Port of Churchill. Due to their age, these boxcars must soon be reconditioned or replaced. A preliminary review of various alternatives for repair or replacement is presented in Study D. The results of this review indicate that, within the range of uncertainty of information currently available on the various options, the most economic alternative for handling grain traffic into the 1990's may be to replace the boxcars with articulated hopper cars. It is estimated that the use of these cars for grain shipments to the Port of Churchill would result in additional railway costs of $3.06 per tonne of throughput during the existing season. This unit cost is independent of the volume of throughput since the number of cars purchased can be adjusted to match planned shipping requirements. This cost was developed on the basis of a 12 week shipping season. The extension of the shipping season would not result in any additional costs since the higher costs of the articulated hopper cars would be fully recovered during the 12 week season.

Although these costs will not be incurred until the late 1980's when replacement of the existing boxcar fleet is expected, the costs are included in the base case of the economic assessment. As discussed more fully in Studies D and B and noted earlier in Chapter 2, the preferred rail car option for handling grain through Churchill beyond the late

1980's (assuming that policy decisions were made to continue the Churchill grain program) might turn out to be in favour of refurbishing the rail line so it can be used with conventional hopper cars. This option would also be compatible with the use of the line for other bulk commodities which might be shipped through Churchill in the future. Alternatively, the preferred option might be to rehabilitate the required number of box cars. For purposes of the economic analysis of season extension, the impact of such decisions would be negligible since (as noted in Study D) the annualized costs of all three options are estimated to be quite similar within the range of uncertainty of the available data. Furthermore, these costs would be allocated to the current season and would not result in any marginal costs during an extended season.

7.1.5 Costs to the Community of Churchill

It is not expected that season extension will result in the need for any additional facilities to be provided by the community of Churchill. Season extension will cause an increase in the consumption of water and electricity but the costs of this additional consumption have already been identified as part of the operating costs of the elevator. The community could also accommodate any potential growth in the number of full time residents resulting from season extension without any investment in additional facilities or infrastructure. The size of the community has decreased in the recent past and any increase in the number of full time residents resulting from season extension is not likely to cause an increase in the demand for or cost of housing or other infrastructure in the community.

7.2 DIRECT BENEFITS OF SEASON EXTENSION

The direct benefits or disbenefits associated with season extension can be grouped into two categories:

- those relating directly to maintaining or increasing grain shipments via the Port of Churchill;
- those relating directly to the reduction in grain shipments via Thunder Bay.

7.2.1 Churchill Related Benefits

Extension of the season at the Port of Churchill would result in the following direct benefits to either the Port or the community of Churchill:

- o additional revenues to the Port from the elevation, cleaning and storage of grain and from harbour charges;
- o an increase in employment in Churchill;
- o an increase in expenditures in Churchill both by residents and by users of the Port.

Additional Port Revenues

The Port of Churchill receives $8.80 per tonne for the elevation, cleaning and storage of grain shipped through the Port. An additional $.55 per tonne is received for harbour dues, berthing and wharfage.

From the perspective of the Port of Churchill, all of these revenues are a direct benefit; however, in terms of the Canadian economy the benefits of these revenues represent a contribution towards recovery of the capital invested in the Port facilities and a proportionate amount of national office overhead. Costs allocated to Churchill in these categories totalled $1.33 million in 1984. These costs would be incurred whether Churchill remained in operation or not and are allocated to the current season, reflecting the marginal costing approach of the season extension analysis.

Increase in Churchill Employment

As indicated earlier in the section on direct costs, it is estimated that the extension of the season would result in additional wages and benefits of $29,900 per week and $1.97 per tonne. These additional wages and benefits would be paid to both full time and part time or seasonal staff.

At a grain throughput of 75,000 tonnes per week, the extension of the shipping season would increase temporary employment for approximately 115 persons by one week. This value represents the difference between peak employment during the current shipping season and base or year-round employment at this throughput level. The number of persons who would be employed for an additional week would go up or down by approximately five employees if grain throughput is increased or decreased by 10,000 tonnes per week.

In addition to causing an increase in temporary employment, it is estimated that there would be approximately three additional permanent residents in the community of Churchill for each week of season extension. This estimate is based on a review of staffing levels at the Port and judgements on the effect of length of employment on residency. The analysis of employment is discussed in greater detail in Appendix B.

The employment multiplier for Manitoba for employment in transportation and storage is 1.94 total direct and indirect employment per direct job. Because of its small size, the community of Churchill will capture only a portion of the additional indirect employment generated by the increase in direct employment at the Port and elevator. If the employment multiplier within Churchill is 1.3, a likely level for such a community, an additional 35 person weeks of employment would be generated for each week of season extension at a throughput of 75,000 tonnes/week.

Additional Expenditures in Churchill

The additional person weeks of employment associated with season extension will cause additional expenditures within the community of Churchill on food, housing, entertainment and other services. Based on discussions with staff from the Port of Churchill, it is estimated that each person week of additional employment will generate expenditures within the community of Churchill in the order of $300.

The community will also benefit from increased expenditures at the Port for the provisioning of vessels and by crewmen from the vessels visiting Churchill. Based on discussions with Port staff and the experience of Captain Pelletier, it is estimated that expenditures on provisioning will be approximately $2,000 per vessel or $0.08 per tonne. Crew members of the vessels are estimated to spend a similar amount on shore within the community of Churchill for both goods and services. These latter expenditures are likely to have a greater benefit within the community due to a higher proportion of local added value.

The extension of the shipping season will also result in additional expenditures on electricity and water for elevator operations. These expenditures will increase the contribution from elevator operations to the fixed costs of operating the electricity generation equipment and water supply infrastructure.

7.2.2 Benefits/Disbenefits Due to Reduced Shipments via Thunder Bay

As part of Study D, a detailed review of historical grain movements through the Port of Churchill was undertaken. This review shows that most of the grain that historically has moved through the Port of Churchill has been destined to Europe. It was also shown that the Churchill and Thunder Bay routes to Europe complement one another, being used to move grain to many of the same destinations. Volumes of particular grain types moving through the Port of Thunder Bay generally are reduced when these same types are moving through Churchill, indicating that grain which does not move through the Port of Churchill would probably move through Thunder Bay and vice versa. Therefore, extension of the shipping season at the Port of Churchill would. under the methodology and assumptions used for the base case season extension evaluation and for the grain shipping cost comparisons described in Study D, result in a reduction in grain movements via Thunder Bay corresponding to the increased movements via Churchill. The direct benefits and disbenefits associated with this reduction are as follows:

- the marine rate from Thunder Bay to Rotterdam relative to that to Rotterdam from Churchill, potentially results in a higher selling price for grain sold FOB Churchill versus grain sold FOB Thunder Bay. This potentially higher selling price could be a benefit to the Canadian economy;
- saving of elevator costs at Thunder Bay;
- saving of rail costs to Thunder Bay;
- decrease in employment and expenditures in Thunder Bay.

Marine Rates

The marine rates for grain shipments from Thunder Bay to Rotterdam are a function of the ocean freight rate market. Exhibit 7.5, drawn from Study D, presents the estimated marine freight rates from Thunder Bay to Rotterdam for three ocean freight market scenarios. Rates are provided for both direct shipment from Thunder Bay and shipment via Thunder Bay and a St. Lawrence port. The actual saving in marine costs to the national economy which would result from a transfer of grain shipments to Churchill are equal to the ocean freight rates less the estimated amount in St. Lawrence Seaway tolls which would not be saved by the Seaway through a transfer of grain shipments to Churchill. This assumption marginally understates the benefit to the Canadian economy since Seaway toll revenues are shared with the United States. The marine cost savings associated with a medium ocean freight market and shipments via Thunder Bay and a St. Lawrence port are used for the base case analysis of season extension at the Port of Churchill since, as shown in Study D, these are most representative of normal circumstances.

Elevator Cost Savings

Shipments of grain via Thunder Bay incur elevator charges of $7.80 per tonne. It was estimated in Study D that approximately 40 percent or $3.12 of this charge represents the variable cost of grain elevation at Thunder Bay. This variable cost would not be incurred if grain shipments were transferred from Thunder Bay to Churchill both during the existing season and during an extended season.

Rail Cost Savings

As indicated earlier, Saskatoon has been selected as a representative location for the assessment of grain shipments via Churchill versus shipments via Thunder Bay. The rail rate for grain from Saskatoon to Thunder Bay is $27.57 per tonne. If we use this rate as a proxy for rail costs from Saskatoon to Thunder Bay, the transfer of grain shipments to Churchill will result in a reduction of railway costs of $27.57 per tonne of throughput at Churchill during the season extension (which, as described below in Section 7.4, is netted against the cost per tonne of moving the grain by rail from Saskatoon to Churchill).

Decrease in Employment/Expenditures in Thunder Bay

Just as an increase in grain throughput via Churchill would cause an increase in employment and expenditures in that community, a decrease in grain throughput via Thunder Bay would cause a decrease in employment and expenditures in Thunder Bay. It is estimated that, tonne for tonne, the decrease in direct employment and expenditures in Thunder Bay would be similar to any increases experienced in Churchill since the variable costs in the two ports are similar, as described more fully in Study D.

7.3 INDIRECT AND INTANGIBLE IMPACTS

There are two categories of indirect costs/benefits and intangibles relevant to the evaluation of season extension at the Port of Churchill. These categories are:

- o factors which make grain shipments via the Port of Churchill more attractive when compared with shipments via Thunder Bay;
- o factors which make the Port of Churchill less attractive versus Thunder Bay.

In this section of the report, important factors from both categories are identified and briefly described. In the presentation of these factors, no distinction is made between costs/benefits which accrue during the current season and those which might accrue during an extended season unless there are significant differences between the two situations.

7.3.1 Factors Favouring the Port of Churchill

There are a number of intangible factors which favour the use of the Port of Churchill as a major grain shipment Port both during the current season and during an extended season. These factors include those which are national in scope, those which benefit the overall grain transportation system and in turn Western grain producers, those which benefit the northern transportation system, and finally those factors which benefit the community of Churchill. The main factors identified as relevant to this study (eg. impacts of an extended season) are as follows:

- enhancements to national sovereignty, defence and Northern development;
- the provision of an alternative and additional route to the St. Lawrence Seaway, particularly since the Seaway can be blocked for extended periods of time due to system failure or labour stoppage;
- enhancements to the viability of resupply operations from the Port of Churchill to communities in the Hudson Bay area;
- increased utilization of the standby capacity of the Coast Guard fleet in operations which are of benefit to the national economy;
- enhancements to the long term viability of the community of Churchill and therefore its ability to provide other functions such as tourism and Artic resupply.

7.3.2 Factors Favouring a Reduction in the Use of the Port of Churchill

A number of intangible factors have also been identified which favour a reduction in the use of the Port of Churchill. These factors, as they relate to season extension, are as follows:

- it may be difficult to convince grain buyers to use the Port of Churchill consistently , particularly during an extended season, because of perceived risks associated with sailing through Arctic waters. If a shipment program with relatively uniform weekly grain throughputs through the Port of Churchill cannot be developed, inefficiencies may occur in the cost of operations of the Port;

- there is the risk that in some years the extended shipping season at the Port of Churchill might have to be cut short due to ice conditions which might result in the storage of grain at Churchill over the winter, the associated costs of this storage as opposed to on-farm storage, and possible difficulties in marketing the stored grain out of Churchill during the following season;

- a significant extension of the shipping season might increase the risks of a serious shipping accident in the Arctic waters of Hudson Bay and Hudson Strait;

- a general perception (related to the current weak market for grain exports) that excess capacity exists on other Canadian grain export routes.

While their quantification is not feasible, the above intangible factors should be considered in combination with the direct costs and benefits of season extension as part of any decision-making process with respect to the shipping season at the Port of Churchill.

7.4 NET BENEFITS OF SEASON EXTENSION

As indicated at the beginning of this chapter, the net benefits of season extension are examined in an aggregate fashion from the following five perspectives:

- o Canadian economy;
- o Western grain producers;
- o Churchill region;
- o community of Churchill;
- o Port of Churchill.

For each perspective, the net benefits of season extension are estimated for the base case scenario. The following assumptions apply for this base case scenario:

- o the Port of Churchill is in operation for a 12 week season with average grain throughput of 75,000 tonnes/week;
- o grain shipments during season extension are at an average volume of 75,000 tonnes per week;
- o ocean freight rates are at average levels.

These assumptions are varied as appropriate in the sensitivity analyses of the net benefits from each of the five different perspectives, as described in the following sub-sections and in Section 7.5.

The throughput level noted above is such that the net benefit estimates are applicable throughout the 1990's.

7.4.1 Canadian Economy

The direct costs and benefits associated with the season extension that are relevant from the perspective of the Canadian economy as a whole are presented in Exhibit 7.6 for the base case scenario. This exhibit also presents the estimated net benefits per tonne of grain throughput for each week of season extension during years with good, moderate and heavy ice conditions.

exhibit 7.6

COSTS AND BENEFITS OF SEASON EXTENSION WITH RESPECT TO THE CANADIAN ECONOMY

(BASED ON 75,000 TONNES/WEEK & AVERAGE MARINE RATES)

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
COST COMPONENTS							($/TONNE)			
BASIC MARINE RATE (AVG. FREIGHT RATES)										
1985 $/TONNE	$24.00	$24.00	$24.00	$23.20	$23.20	$24.00	$24.00	$24.00	$24.00	$24.00
DELAY & WAITING COSTS										
GOOD YEARS	0.61	0.39	0.34	0.00	0.00	0.00	0.00	0.02	0.13	0.66
MODERATE	2.10	0.90	0.49	0.00	0.00	0.01	0.09	0.36	1.27	3.88
HEAVY ICE	5.68	2.74	1.37	0.09	0.18	0.43	1.19	3.12	6.04	9.28
ICEBREAKER ESCORT COSTS										
GOOD YEARS	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
MODERATE	2.11	0.62	0.17	0.00	0.00	0.00	0.01	0.12	0.88	3.87
HEAVY ICE	6.21	2.88	1.32	0.06	0.10	0.28	0.85	3.12	6.87	10.83
NAVIGATIONAL SERVICES										
1985 $/TONNE	0.00	0.00	0.00	0.27	0.27	0.27	0.27	0.27	0.27	0.27
INCREMENTAL HARBOUR COSTS										
WINTER BERTH						0.08	0.04	0.03	0.02	0.02
ADDITIONAL DREDGING								4.89	2.44	1.63
ICEBREAKER SERVICES	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.56	0.79
PORT & ELEVATOR COSTS										
FIXED	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
VARIABLE	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04
NTCL ADJUSTMENT										
DUST CONTROL										
CBC EXTRA COSTS										
RAILWAY COSTS										
BASIC RAIL RATE	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25
ADDITIONAL CAR COSTS										
TOTAL COSTS FOR	75,000 TONNES PER WEEK									
GOOD YEARS	$54.60	$54.17	$54.12	$53.24	$53.24	$54.13	$54.09	$59.18	$57.20	$57.35
MODERATE	$57.99	$55.30	$54.44	$53.24	$53.25	$54.14	$54.18	$59.64	$59.21	$64.22
HEAVY ICE	$65.67	$59.39	$56.47	$53.39	$53.52	$54.83	$56.13	$65.40	$69.98	$76.59
BENEFIT COMPONENTS										
TRANSPORTATION COST SAVINGS										
MARINE (AVG. - TRANS-SHIPMENT)	34.52	34.52	34.52	34.52	34.52	34.52	34.52	34.52	34.52	34.52
ELEVATOR	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12	3.12
RAILWAY	27.57	27.57	27.57	27.57	27.57	27.57	27.57	27.57	27.57	27.57
TOTAL BENEFITS	$65.21	$65.21	$65.21	$65.21	$65.21	$65.21	$65.21	$65.21	$65.21	$65.21
NET BENEFITS	75,000 TONNES PER WEEK									
GOOD YEARS	$10.61	$11.04	$11.09	$11.97	$11.97	$11.08	$11.12	$6.03	$8.01	$7.86
MODERATE	7.22	9.91	10.77	11.97	11.96	11.07	11.03	5.57	6.00	0.99
HEAVY ICE	-0.46	5.82	8.74	11.82	11.69	10.38	9.08	-0.19	-4.77	-11.38

Those items which are included as cost components in Exhibit 7.6 are as follows:

- the basic marine rate from Churchill to Rotterdam;
- delay and waiting costs for the commercial vessel associated with ice conditions;
- icebreaker escort costs;
- the cost of extending telecommunications services beyond the end of the current season;
- incremental harbour costs including improvements to the winter berth, additional dredging required for the use of icebreakers in the harbour, and the cost of icebreaker services in the harbour;
- Port and elevator costs including both the fixed and variable components;
- railway costs which are represented by the basic rail rate from Saskatoon to Churchill.

The benefit components used to determine the net benefits of season extension to the Canadian economy are as follows:

- the marine rate from Thunder Bay to Rotterdam excluding St. Lawrence Seaway tolls;
- the variable cost component of elevator charges at Thunder Bay;
- the railway rate from Saskatoon to Thunder Bay.

As illustrated in Exhibit 7.6, season extension would result in positive net benefits to the Canadian economy during all weeks under review for years with good and moderate ice conditions and for the period July 13th through November 15th in years with heavy ice conditions.

The sensitivity of these net benefits to changes in ocean freight rates and throughput volumes is illustrated in Exhibit 7.7. In the exhibit, the net benefits of season extension are presented for the following four combinations of marine freight rate scenarios and routings via Thunder Bay:

exhibit 7.7

COMPARISON OF NET BENEFITS OF SEASON EXTENSION TO THE NATIONAL ECONOMY VERSUS MARINE FREIGHT RATE SCENARIOS AND GRAIN THROUGHPUT

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
							($/TONNE)			
MARINE(LOW - DIRECT)	65,000 TONNES PER WEEK									
GOOD YEARS	$4.77	$5.19	$5.25	$6.08	$6.08	$5.18	$5.23	($0.64)	$1.65	$1.60
MODERATE	1.37	4.06	4.93	6.08	6.08	5.17	5.14	-1.10	-0.35	-5.27
HEAVY ICE	-6.31	-0.03	2.90	5.93	5.81	4.48	3.19	-6.86	-11.12	-17.64
MARINE(LOW - DIRECT)	75,000 TONNES PER WEEK									
GOOD YEARS	$4.84	$5.27	$5.32	$6.20	$6.20	$5.31	$5.35	$0.26	$2.24	$2.09
MODERATE	1.45	4.14	5.00	6.20	6.19	5.30	5.26	-0.20	0.23	-4.78
HEAVY ICE	-6.23	0.05	2.97	6.05	5.92	4.61	3.31	-5.96	-10.54	-17.15
MARINE(LOW - DIRECT)	85,000 TONNES PER WEEK									
GOOD YEARS	$4.90	$5.33	$5.38	$6.29	$6.29	$5.41	$5.45	$0.95	$2.68	$2.46
MODERATE	1.51	4.20	5.06	6.29	6.28	5.40	5.35	0.50	0.67	-4.41
HEAVY ICE	-6.17	0.10	3.03	6.14	6.01	4.70	3.41	-5.27	-10.09	-16.78
MARINE(LOW - TRANS-SHIPMENT)	65,000 TONNES PER WEEK									
GOOD YEARS	$14.94	$15.36	$15.42	$16.25	$16.25	$15.35	$15.40	$9.53	$11.82	$11.77
MODERATE	11.54	14.23	15.10	16.25	16.25	15.34	15.31	9.07	9.82	4.90
HEAVY ICE	3.86	10.14	13.07	16.10	15.98	14.65	13.36	3.31	-0.95	-7.47
MARINE(LOW - TRANS-SHIPMENT)	75,000 TONNES PER WEEK									
GOOD YEARS	$15.01	$15.44	$15.49	$16.37	$16.37	$15.48	$15.52	$10.43	$12.41	$12.26
MODERATE	11.62	14.31	15.17	16.37	16.36	15.47	15.43	9.97	10.40	5.39
HEAVY ICE	3.94	10.22	13.14	16.22	16.09	14.78	13.48	4.21	-0.37	-6.98
MARINE(LOW - TRANS-SHIPMENT)	85,000 TONNES PER WEEK									
GOOD YEARS	$15.07	$15.50	$15.55	$16.46	$16.46	$15.58	$15.62	$11.12	$12.85	$12.63
MODERATE	11.68	14.37	15.23	16.46	16.45	15.57	15.52	10.67	10.84	5.76
HEAVY ICE	4.00	10.27	13.20	16.31	16.18	14.87	13.58	4.90	0.08	-6.61

exhibit 7.7 cont'd

COMPARISON OF NET BENEFITS OF SEASON EXTENSION TO THE NATIONAL ECONOMY VERSUS MARINE FREIGHT RATE SCENARIOS AND GRAIN THROUGHPUT

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
MARINE(AVG. - TRANS-SHIPMENT)	65,000 TONNES PER WEEK						($/TONNE)			
GOOD YEARS	$10.54	$10.96	$11.02	$11.85	$11.85	$10.95	$11.00	$5.13	$7.42	$7.37
MODERATE	7.14	9.83	10.70	11.85	11.85	10.94	10.91	4.67	5.42	0.50
HEAVY ICE	-0.54	5.74	8.67	11.70	11.58	10.25	8.96	-1.09	-5.35	-11.87
MARINE(AVG. - TRANS-SHIPMENT)	75,000 TONNES PER WEEK									
GOOD YEARS	$10.61	$11.04	$11.09	$11.97	$11.97	$11.08	$11.12	$6.03	$8.01	$7.86
MODERATE	7.22	9.91	10.77	11.97	11.96	11.07	11.03	5.57	6.00	0.99
HEAVY ICE	-0.46	5.82	8.74	11.82	11.69	10.38	9.08	-0.19	-4.77	-11.38
MARINE(AVG. - TRANS-SHIPMENT)	85,000 TONNES PER WEEK									
GOOD YEARS	$10.67	$11.10	$11.15	$12.06	$12.06	$11.18	$11.22	$6.72	$8.45	$8.23
MODERATE	7.28	9.97	10.83	12.06	12.05	11.17	11.12	6.27	6.44	1.36
HEAVY ICE	-0.40	5.87	8.80	11.91	11.78	10.47	9.18	0.50	-4.32	-11.01
MARINE(HIGH - TRANS-SHIPMENT)	65,000 TONNES PER WEEK									
GOOD YEARS	$3.74	$4.16	$4.22	$5.05	$5.05	$4.15	$4.20	($1.67)	$0.62	$0.57
MODERATE	0.34	3.03	3.90	5.05	5.05	4.14	4.11	-2.13	-1.38	-6.30
HEAVY ICE	-7.34	-1.06	1.87	4.90	4.78	3.45	2.16	-7.89	-12.15	-18.67
MARINE(HIGH - TRANS-SHIPMENT)	75,000 TONNES PER WEEK									
GOOD YEARS	$3.81	$4.24	$4.29	$5.17	$5.17	$4.28	$4.32	($0.77)	$1.21	$1.06
MODERATE	0.42	3.11	3.97	5.17	5.16	4.27	4.23	-1.23	-0.80	-5.81
HEAVY ICE	-7.26	-0.98	1.94	5.02	4.89	3.58	2.28	-6.99	-11.57	-18.18
MARINE(HIGH - TRANS-SHIPMENT)	85,000 TONNES PER WEEK									
GOOD YEARS	$3.87	$4.30	$4.35	$5.26	$5.26	$4.38	$4.42	($0.08)	$1.65	$1.43
MODERATE	0.48	3.17	4.03	5.26	5.25	4.37	4.32	-0.53	-0.36	-5.44
HEAVY ICE	-7.20	-0.93	2.00	5.11	4.98	3.67	2.38	-6.30	-11.12	-17.81

- o low/direct - low market rates for ocean freight and the use of direct shipments via ocean vessels from Thunder Bay to Rotterdam;
- o low/trans-shipment - low market rates with grain shipments undertaken using lakers to a St. Lawrence port and then ocean vessels to Rotterdam;
- o average/trans-shipment - average market rates with trans-shipment of grain via a St. Lawrence port;
- o high/trans-shipment - high market rates with trans-shipment via a St. Lawrence port.

In general, the lowest marine freight rate routing from Thunder Bay to Rotterdam in each of the market scenarios is used to calculate the net benefits. For the low marine freight market scenario, two routings via Thunder Bay are carried forward:

- o low/direct as this represents the lowest cost possibility under this market scenario and could be used for the marginal amounts of grain that might be transferred to Churchill;
- o low/trans-shipment as this is the way by which most Canadian Wheat Board grain moves, even in periods of low marine freight rates.

As indicated in the exhibit, the highest benefits of season extension are achieved under conditions of low market rates for ocean freight when grain shipments via Thunder Bay would be trans-shipped through a St. Lawrence port. The benefits under these conditions are approximately $11.00 higher than the benefits achieved when ocean freight rates are high. The exhibit also illustrates that in all conditions extension of the shipping season to go from July 20th through November 15th yields positive net benefits to the Canadian economy.

The sensitivity of the base case scenario to changes in grain throughput is also illustrated in Exhibit 7.7. As shown in the exhibit the net benefits of season extension per tonne increase marginally with increasing throughput. It should be noted that the increase in benefits

per tonne for increasing throughput during the current season would be higher than the increase in benefits per tonne during the extended season. This is because the overall variable costs during the current season are less than the cost per tonne that would be incurred during season extension. This indicates that it is more cost-effective to increase volumes to near capacity during the current season and then proceed with season extension.

7.4.2 Western Grain Producers

The revenue received by Western grain producers for their grain is net of the overall transportation cost for the grain. Therefore, from the perspective of western grain producers, the benefits of season extension at the Port of Churchill are the savings in transportation costs which would otherwise be incurred if the grain were shipped via Thunder Bay. At the same time, the costs associated with season extension are the additional transportation costs which would be incurred via the Churchill route during an extended season.

Grain producers pay fixed rates for the rail and elevator components of grain transportation; however, these rates will be adjusted from year to year to reflect the actual costs incurred for these components. In addition, the marine freight rates are generally accounted for in the price received for grain shipped through Churchill and Thunder Bay. Therefore, in assessing the costs and benefits from the perspective of Western grain producers all of the rail, elevator and harbour, and marine freight rate costs have been considered. The cost and benefit components with respect to Western grain producers and the resulting estimated net benefits are presented in Exhibit 7.8. Under the cost components, three possible marine rates for shipments from Churchill to Rotterdam are presented (low, average and high). In addition, three possible delay and waiting costs are presented for each week under study reflecting good, moderate and heavy ice years. Under the benefit components, the four combinations of marine freight market scenario and routing via Thunder Bay identified earlier, are presented.

exhibit 7.8

COSTS AND BENEFITS OF SEASON EXTENSION WITH RESPECT TO WESTERN GRAIN PRODUCERS

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
COST COMPONENTS										
==========										
							($/TONNE)			
BASIC MARINE RATE (1985 $/TONNE)										
LOW FREIGHT RATES	$16.10	$16.10	$16.10	$15.30	$15.30	$16.10	$16.10	$16.10	$16.10	$16.10
AVERAGE FREIGHT RATES	24.00	24.00	24.00	23.20	23.20	24.00	24.00	24.00	24.00	24.00
HIGH FREIGHT RATES	40.20	40.20	40.20	39.40	39.40	40.20	40.20	40.20	40.20	40.20
DELAY & WAITING COSTS										
GOOD YEARS	0.61	0.39	0.34				0.00	0.02	0.13	0.66
MODERATE	2.10	0.90	0.49	0.00	0.00	0.01	0.09	0.36	1.27	3.88
HEAVY ICE	5.68	2.74	1.37	0.09	0.18	0.43	1.19	3.12	6.04	9.28
INCREMENTAL HARBOUR COSTS										
WINTER BERTH						0.08	0.04	0.03	0.02	0.02
ADDITIONAL DREDGING								4.89	2.44	1.63
PORT & ELEVATOR COSTS										
FIXED	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
VARIABLE	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04
RAILWAY COSTS										
BASIC RAIL RATE	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25	26.25
BENEFIT COMPONENTS										
==========										
MARINE(LOW - DIRECT)	22.23	22.23	22.23	22.23	22.23	22.23	22.23	22.23	22.23	22.23
MARINE(LOW - TRANS-SHIPMENT)	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20	32.20
MARINE(AVG. - TRANS-SHIPMENT)	35.70	35.70	35.70	35.70	35.70	35.70	35.70	35.70	35.70	35.70
MARINE(HIGH - TRANS-SHIPMENT)	45.10	45.10	45.10	45.10	45.10	45.10	45.10	45.10	45.10	45.10
ELEVATOR	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80	7.80
RAILWAY	27.57	27.57	27.57	27.57	27.57	27.57	27.57	27.57	27.57	27.57
NET BENEFITS										
==========	75,000 TONNES/WEEK									
MARINE(LOW - DIRECT)										
GOOD YEARS	11.11	11.33	11.38	12.52	12.52	11.64	11.68	6.79	9.12	9.42
MODERATE	9.62	10.82	11.23	12.52	12.52	11.63	11.59	6.45	7.99	6.20
HEAVY ICE	6.04	8.98	10.35	12.43	12.35	11.21	10.49	3.68	3.22	0.79
MARINE(LOW - TRANS-SHIPMENT)										
GOOD YEARS	21.08	21.30	21.35	22.49	22.49	21.61	21.65	16.76	19.09	19.39
MODERATE	19.59	20.79	21.20	22.49	22.49	21.60	21.56	16.42	17.96	16.17
HEAVY ICE	16.01	18.95	20.32	22.40	22.32	21.18	20.46	13.65	13.19	10.76
MARINE(AVG. - TRANS-SHIPMENT)										
GOOD YEARS	16.68	16.90	16.95	18.09	18.09	17.21	17.25	12.36	14.69	14.99
MODERATE	15.19	16.39	16.80	18.09	18.09	17.20	17.16	12.02	13.56	11.77
HEAVY ICE	11.61	14.35	15.92	18.00	17.92	16.78	16.06	9.25	8.79	6.36
MARINE(HIGH - TRANS-SHIPMENT)										
GOOD YEARS	9.88	10.10	10.15	11.29	11.29	10.41	10.45	5.56	7.89	8.19
MODERATE	8.39	9.59	10.00	11.29	11.29	10.40	10.36	5.22	6.76	4.97
HEAVY ICE	4.81	7.75	9.12	11.20	11.12	9.98	9.26	2.45	1.99	-0.44

The cost and benefit components are combined as appropriate to develop estimates of net benefits for each week under study for the three possible ice conditions and the four combinations of marine freight market scenario and routings via Thunder Bay. Exhibit 7.8 has been prepared based on a grain throughput of 75,000 tonnes per week.

As indicated in the exhibit, extension of the shipping season at Churchill yields positive estimated net benefits for Western grain producers in virtually all combinations of marine freight rates and ice conditions. For the proposed 17 week extended season, Exhibit 7.8 shows net benefits to Western grain producers in the range of about $10-$22 per tonne, depending on the ocean freight rate market and ice conditions.

The net benefits presented in Exhibit 7.8 assume that the price paid for grain shipped through Churchill would differ from the price of grain shipped through Thunder Bay to the extent that marine freight rates from the two origins to Rotterdam differ. Any discounts from this marine freight rate spread on the price of grain shipped through Churchill (eg. as might apply in the current "buyers' market" for grain) would have to be deducted from the net benefits, but such discounts are not anticipated to be a significant factor in a "sellers' market" for grain (as has been experienced during the late 1970's and early 1980's) or (relative to the net benefits to Western producers) in average grain market years.

The net benefits presented in Exhibit 7.8 are not very sensitive to changes in weekly grain throughput, as was the case in the net benefits to the Canadian economy. Once again, a greater increase in net benefits is achieved by increasing grain throughput during the current season first before extending the season, due to lower variable costs at Churchill during the current season versus the extended part of the season.

7.4.3 Churchill Region

For the purposes of this evaluation the Churchill region is identified as that area where rail rates for grain to Churchill are lower than grain rates to Thunder Bay, Vancouver or Prince Rupert. The grain

producers within this region will receive the same net benefits as the grain producers throughout Western Canada due to the equalization of transportation costs. Excluding the grain producers and the federal government and its agencies, the region will benefit from:

- o increased employment in Churchill and the associated increase in expenditures within the region;
- o increased utilization of the electricity generated by the new hydro electric project at Gillam;
- o a shift of railway and port employment from Central Canada to the Churchill region;
- o any benefits which an extended season may provide to the marine resupply season.

These regional benefits will not be offset by regional costs since the costs of season extension in Churchill will be borne primarily by grain producers, Thunder Bay elevators and the federal government. The quantifiable benefits to the Churchill Region are presented in Exhibit 7.9.

The above costs and benefits are insensitive to ocean freight rates. The benefits would increase to some extent with increases in the volume of grain shipments per week. This increase in benefits would be approximately the same whether the increase in volumes occurred during the current season or during an extended season.

7.4.4 Community of Churchill

As in the case of the Churchill region, the community of Churchill will benefit from season extension through increased employment, increased expenditures in the community, and an increase in the contribution to the fixed cost of utilities such as water supply from the revenues generated by greater use of these services. The quantifiable portions of these benefits are the same as those for the Region (Exhibit 7.9).

exhibit 7.4

ESTIMATED COSTS OF OPERATION OF THE PORT AND ELEVATOR AT CHURCHILL

COST COMPONENT	ANNUAL COSTS (1985 $) BASED ON 12 WEEK SEASON FIXED ($/SEASON)	VARIABLE ($/TONNE)	BASIS FOR ESTIMATE	SEASON EXTENSION COSTS (1985 $) FIXED ($/WEEK)	VARIABLE ($/TONNE)
LABOR REGULAR	1,702,400	0.71	TREND 1976 TO 1984	26,000	0.71
OVERTIME	(39,450)	1.00	TREND 1976 TO 1984	0	1.00
OUTSIDE	5,700	0.00	AVERAGE 1976 TO 1984	0	0.00
BENEFITS	249,400	0.26	15% REGULAR + OVERTIME	3,900	0.26
TOTAL LABOR	1,918,050	1.97		29,900	1.97
PURCHASES					
PROFESS. & FEES	453,400	0.00	AVERAGE 1983 TO 1985	0	0.00
REPAIRS & MAINT.	112,200	0.00	AVERAGE 1976 TO 1984	0	0.00
MATERIALS	194,100	0.45	TREND 1980 TO 1984	0	0.45
ENERGY	651,000	0.51	TREND 1982 TO 1985	7,000	0.51
OTHER	56,800	0.00	AVERAGE 1976 TO 1984	0	0.00
TOTAL PURCHASES	1,467,500	0.97		7,000	0.97
DEVELOPMENT & MISC.					
DEVELOPMENT	61,700	0.00	AVERAGE 1976 TO 1984	0	0.00
MISCELLANEOUS	0	0.10	TREND 1980 TO 1984	0	0.10
TOTAL DEV. & MISC.	61,700	0.10		0	0.10
TOTAL DIRECT OPERATING	3,447,250	3.04		36,900	3.04
INDIRECT COSTS					
DEPRECIATION	1,107,700	0.00	AVERAGE 1976 TO 1984	0	0
GRANTS	633,300	0.00	AVERAGE 1976 TO 1984	0	0
OVERHEAD	273,700	0.00	AVERAGE 1976 TO 1984	0	0
TOTAL INDIRECT COSTS	2,014,700	0.00		0	0.00
TOTAL COSTS	5,461,950	3.04		36,900	3.04

This cost model was developed on the basis of annual net grain throughput since elevator tariffs are quoted on the basis of dollars per tonne of grain.

exhibit 7.9

QUANTIFIABLE NET BENEFITS OF SEASON EXTENSION TO THE CHURCHILL COMMUNITY AND REGION *

BENEFIT COMPONENT	NET BENEFITS PER WEEK OF SEASON EXTENSION**		
	THROUGHPUT VOLUME (TONNES/WEEK)		
	65,000	75,000	85,000
Increased Temporary Direct Employment (Person-Weeks)	110	115	120
Increase in Full-Time Residency in Churchill (Resident Persons)	3	3	3
Increased Expenditure in Churchill by Users of the Port	$10,400	$12,000	$13,600

NOTE: These benefits are expressed in different units and are therefore not additive.

* Excludes grain producers whose net benefits are assessed separately.

** The net benefits are equal to the aggregate of the benefit components since the region does not directly pay for any of the costs of season extension.

Since the community of Churchill has supported higher populations in the recent past, and since there has not been a significant decrease in the infrastructure of the community, it is not expected that season extension would cause any direct costs to the community that were not recoverable through direct revenue.

The benefits to the community are insensitive to changes in ocean freight rates. The benefits increase marginally with increases in grain throughput.

7.4.5 Port of Churchill

The cost of season extension to the Port of Churchill is estimated to be below $3.65 per tonne during each additional week from the period July 6 through November 15. After November 15 the cost of season extension to the Port increases significantly due to additional dredging requirements within the turning basin. The highest incremental cost when this cost element is included is approximately $8.50 per tonne for a throughput of 75,000 tonnes per week. This cost would be incurred if the season was extended only to November 22. Further extension of the season would reduce this marginal cost.

The benefits to the Port of Churchill of season extension result from the increase in revenues generated through the elevation, cleaning and storage of grain and harbour fees. These revenues are estimated to be $9.35 per tonne. Therefore, season extension results in positive net benefits to the Port of Churchill during all weeks under review. These net benefits are insensitive to ocean freight rates. The net benefits per tonne increase with grain throughput since the fixed component of the costs can be allocated over a greater volume. This cost increase is typically less than 10¢ per tonne as grain volumes increase to 85,000 tonnes per week from 75,000 tonnes per week. The variation in the net benefits by week for the three levels of throughput is illustrated in Exhibit 7.10.

exhibit 7.10

NET BENEFITS OF SEASON EXTENSION TO THE PORT OF CHURCHILL

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
						($/TONNE)				
INCREMENTAL HARBOUR COSTS										
WINTER BERTH($/WEEK)						6,300	3,150	2,100	1,575	1,260
ADDITIONAL DREDGING($/WEEK)								366,600	183,300	122,200
PORT & ELEVATOR COSTS										
FIXED($/WEEK)	36,900	36,900	36,900	36,900	36,900	36,900	36,900	36,900	36,900	36,900
VARIABLE($/TONNE)	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04	3.04
PORT REVENUES/TONNE										
GRAIN ELEVATION	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80	8.80
HARBOUR FEES	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
NET BENEFITS ($/TONNE)										
65,000 TONNES PER WEEK	5.75	5.75	5.75	5.75	5.75	5.65	5.70	0.07	2.90	3.85
75,000 TONNES PER WEEK	5.82	5.82	5.82	5.82	5.82	5.74	5.78	0.91	3.36	4.18
85,000 TONNES PER WEEK	5.88	5.88	5.88	5.88	5.88	5.81	5.84	1.54	3.71	4.43

7.5 SENSITIVITY ASSESSMENT AND CONCLUSIONS

7.5.1 Overall Sensitivity Assessment

As indicated earlier in Exhibit 7.7, the net benefits per tonne of grain throughput of season extension to the Canadian economy are not very sensitive to changes in the level of grain throughput. There is a similar lack of sensitivity with respect to grain throughput for the net benefits per tonne of season extension to Western grain producers. In order to confirm this relative lack of sensitivity to the level of grain throughput, an additional analysis was performed at a throughput level of 40,000 tonnes per week. The results of this analysis are summarized in Exhibit 7.11. This exhibit presents the net benefits per tonne of season extension to the Canadian economy at a grain throughput level of 40,000 tonnes per week. A comparison of this exhibit to Exhibit 7.7 indicates that the net benefits per tonne decrease with decreasing volumes of throughput, but this decrease is not substantial relative to the magnitude of the net benefits under most combinations of marine rates and ice conditions.

The net benefits per tonne of season extension from the perspective of the Churchill region, the community of Churchill and the Port of Churchill are also relatively insensitive to volume of throughput. This is because the costs and benefits of season extension from these perspectives tend to be constant values per tonne of grain throughput.

Due to the relatively low sensitivity of net benefits per tonne of season extension when compared with volume throughput, the remainder of the assessment focuses on a level of throughput of 75,000 tonnes per week. The net benefits per tonne of season extension to the Canadian economy at a throughput level of 75,000 tonnes per week are summarized in Exhibit 7.12. This exhibit illustrates the fact that the net benefits per tonne are highly sensitive to both marine freight market scenarios and the

exhibit 7.11

NET BENEFITS OF SEASON EXTENSION WITH RESPECT TO THE CANADIAN ECONOMY AT A THROUGHPUT OF 40,000 TONNES/WEEK*

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
MARINE(LOW - DIRECT)	40,000 TONNES PER WEEK						($/TONNE)			
GOOD YEARS	$4.41	$4.84	$4.89	$5.53	$5.53	$4.57	$4.65	($4.88)	($1.07)	($0.71)
MODERATE	1.02	3.71	4.57	5.53	5.53	4.57	4.56	-5.34	-3.08	-7.58
HEAVY ICE	-6.66	-0.39	2.54	5.38	5.26	3.87	2.61	-11.10	-13.85	-19.95
MARINE(LOW - TRANS-SHIPMENT)	40,000 TONNES PER WEEK									
GOOD YEARS	$14.58	$15.01	$15.06	$15.70	$15.70	$14.74	$14.82	$5.29	$9.10	$9.46
MODERATE	11.19	13.88	14.74	15.70	15.70	14.74	14.73	4.83	7.09	2.59
HEAVY ICE	3.51	9.78	12.71	15.55	15.43	14.04	12.78	-0.93	-3.68	-9.78
MARINE(AVG. - TRANS-SHIPMENT)	40,000 TONNES PER WEEK									
GOOD YEARS	$10.18	$10.61	$10.66	$11.30	$11.30	$10.34	$10.42	$0.89	$4.70	$5.06
MODERATE	6.79	9.48	10.34	11.30	11.30	10.34	10.33	0.43	2.69	-1.81
HEAVY ICE	-0.89	5.38	8.31	11.15	11.03	9.64	8.38	-5.33	-8.08	-14.18
MARINE(HIGH - TRANS-SHIPMENT)	40,000 TONNES PER WEEK									
GOOD YEARS	$3.38	$3.81	$3.86	$4.50	$4.50	$3.54	$3.62	($5.91)	($2.10)	($1.74)
MODERATE	-0.01	2.68	3.54	4.50	4.50	3.54	3.53	-6.37	-4.11	-8.61
HEAVY ICE	-7.69	-1.42	1.51	4.35	4.23	2.84	1.58	-12.13	-14.88	-20.98

* These estimates assume more or less current operations. If the scale of operations at the Port were to be continuously reduced to this level, re-organization of its operations would be necessary in the interest of saving operating costs. The effect of such re-organization is not reflected in the above table.

exhibit 7.12

NET BENEFITS OF SEASON EXTENSION WITH RESPECT TO THE CANADIAN ECONOMY AT A THROUGHPUT OF 75,000 TONNES/WEEK

WEEK ENDING	12-Jul	19-Jul	26-Jul	25-Oct	01-Nov	08-Nov	15-Nov	22-Nov	29-Nov	06-Dec
MARINE(LOW - DIRECT)	75,000 TONNES PER WEEK									
GOOD YEARS	$4.84	$5.27	$5.32	$6.20	$6.20	$5.31	$5.35	$0.26	$2.24	$2.09
MODERATE	1.45	4.14	5.00	6.20	6.19	5.30	5.26	-0.20	0.23	-4.78
HEAVY ICE	-6.23	0.05	2.97	6.05	5.92	4.61	3.31	-5.96	-10.54	-17.15
MARINE(LOW - TRANS-SHIPMENT)	75,000 TONNES PER WEEK									
GOOD YEARS	$15.01	$15.44	$15.49	$16.37	$16.37	$15.48	$15.52	$10.43	$12.41	$12.26
MODERATE	11.62	14.31	15.17	16.37	16.36	15.47	15.43	9.97	10.40	5.39
HEAVY ICE	3.94	10.22	13.14	16.22	16.09	14.78	13.48	4.21	-0.37	-6.98
MARINE(AVG. - TRANS-SHIPMENT)	75,000 TONNES PER WEEK									
GOOD YEARS	$10.61	$11.04	$11.09	$11.97	$11.97	$11.08	$11.12	$6.03	$8.01	$7.86
MODERATE	7.22	9.91	10.77	11.97	11.96	11.07	11.03	5.57	6.00	0.99
HEAVY ICE	-0.46	5.82	8.74	11.82	11.69	10.38	9.08	-0.19	-4.77	-11.38
MARINE(HIGH - TRANS-SHIPMENT)	75,000 TONNES PER WEEK									
GOOD YEARS	$3.81	$4.24	$4.29	$5.17	$5.17	$4.28	$4.32	($0.77)	$1.21	$1.06
MODERATE	0.42	3.11	3.97	5.17	5.16	4.27	4.23	-1.23	-0.80	-5.91
HEAVY ICE	-7.26	-0.98	1.94	5.02	4.89	3.58	2.28	-6.99	-11.57	-18.18

type of ice conditions expected during a particular season. This sensitivity to these factors is important since both are difficult to predict with certainty in any given year. Therefore, it is critical to examine not just average marine rate scenarios and moderate ice conditions in the development of conclusions with respect to season extension.

The results presented in Exhibit 7.12 illustrate that there are positive potential net benefits per tonne to the Canadian economy from July 20th to November 15th under all combinations of marine freight rate scenarios and ice conditions. These net benefits are potential in that they result primarily from differences in marine rates from Thunder Bay to Rotterdam versus Churchill to Rotterdam. This differential in marine rates is of benefit to the Canadian economy and Western grain producers only to the extent to which the differential is accounted for in the price received for grain sold FOB Thunder Bay versus FOB Churchill. As pointed out elsewhere in this report and in Study D, while prices may not reflect the full marine freight rate spread in years of weak grain markets, they are more likely to reflect the rate spread in average grain market years and particularly so in years of strong grain markets (sellers' market).

As indicated earlier, the potential net benefits per tonne of season extension to the Canadian economy will increase with increasing volumes of throughput. It should be noted, however, that increases in the volume of throughput during the current season are more beneficial economically than season extension since the marginal costs of additional throughput during the current season are lower than the marginal costs for additional fixed costs incurred during the current season to accommodate the higher volumes of throughput.

7.5.2 Conclusions

Based on the preceding economic analysis and sensitivity assessments, we conclude that it would be beneficial from the perspective of the Canadian economy to extend the shipping season at the Port of Churchill to cover the period July 20 through November 15 given the following conditions:

- the Port of Churchill is used at relatively high throughput levels: at least 700,000-750,000 tonnes per year;

- growth in grain shipments via the Port of Churchill through season extension occurs initially during the shoulders of the current season, i.e. during the period when marginal costs of additional throughput are lowest;

- the difference in the price received for grain shipped via Churchill versus via Thunder Bay reflects all or a significant portion of the difference in marine freight rates from each of these ports to typical European destinations (e.g. Rotterdam).

Prior to July 20th, there is a significant increase in the number of hours required for icebreaker escort except in good ice years. The requirement for icebreaker escort is a direct function of the extent of ice coverage expected along the route between Cape Chidley and the Port of Churchill. The greater extent of ice coverage associated with the icebreaker escort requirements would potentially increase the perceived risks of sailing to Churchill. These perceived risks may be translated into higher marine rates until additional experience is accumulated on the actual impact of ice conditions on vessel sailing speed and other relevant factors. These conditions lead to the conclusion that a one week season extension at the beginning of the season (e.g. from July 27 to July 20) is the maximum warranted at this time.

Extension of the shipping season beyond November 15th will also result in an increase in icebreaker escort requirements, although this increase would be significant only in heavy ice years. More importantly, after November 15th it is expected that an icebreaker would be required to operate within the harbour at Churchill in order to break ice in the turning basin and along side the dock and to maintain an open channel from the harbour to Hudson Bay. This operation would in turn require additional dredging of the turning basin at an estimated capital cost of $3.1 million. November 15 is therefore a logical end point for the extended season.

As discussed more fully in Chapter 8, it may be appropriate to delay any decisions on season extension beyond the middle of November until additional experience is gained from shipments occurring in early November. This experience would help to remove the uncertainties associated with the estimated costs of grain shipments late in November. This experience should be obtained before any major capital investments required solely for season extension are made at the Port of Churchill.

8. CONCLUSIONS AND RECOMMENDATIONS

Based on the study findings as outlined above and reported more fully in the first seven chapters of the report, Chapter 8 summarizes the overall conclusions of the study and presents a recommended action plan to achieve the level of season extension found to be economically viable.

8.1 CONCLUSIONS

The conclusions of the study, which draw also on the grain shipping cost analyses during the normal season of Study D, may be summarized as follows:

1. In terms of grain exports, as concluded in Study D, the Port will be economically viable only for higher levels of grain throughput, beyond approximately 600,000 tonnes per year in the 1990's and assuming that line related costs for the Churchill rail line will be borne by the federal government rather than by grain shippers (recognizing the broader role of the Port and the rail line in terms of national objectives such as defence, sovereignty and development in the North). Maintaining the Port and the railway line and not using it at or above such throughput levels is the worst option in terms of the economics of handling and transporting export grain.

2. There are net economic benefits to the Canadian economy for Churchill grain throughput levels of that magnitude or greater and for years of good, average and heavy ice conditions and under all three ocean freight rate scenarios, if the shipping season at the Port of Churchill is extended by one week in the spring and four weeks in the fall, creating a 17 week shipping season from July 20 to November 15, inclusive. The economic analysis on which this conclusion is based assumes that all or most of the price advantage of Canadian export grain FOB Churchill versus FOB Thunder Bay (based on the marine freight rate spread between the two ports for shipments to Rotterdam) will be achieved by the Canadian export grain marketing program. While it is not possible to obtain hard data on grain selling prices FOB the two ports (owing to commercial confidentiality requirements of the Canadian Wheat Board) the study team concludes based on discussions with grain shippers and others that the

above premise, while somewhat less valid in years of weak grain markets (a buyers' market), is likely to be valid in years of average grain markets and even more likely to be valid in years of strong grain markets (a sellers' market) such as those experienced in the late 1970's and early 1980's.

3. There are natural "break points" at the limits of the proposed extended season: a very minimal capital expenditure would be required to achieve the July 20-November 15 extended season; a more substantial expenditure of about $3.1 million would be required to achieve season extension beyond November 15, however, in order to dredge the harbour turning area to facilitate routine icebreaker operations within the harbour; the operating costs of season extension before July 20 and after November 15 would also be substantially higher because of the requirements of icebreaker escort en route, particularly in years of heavy ice conditions which tend to be experienced about one year in five.

4. To provide greater assurance that harbour operations could be maintained until November 15 without the need for occasional icebreaker operations within the harbour, the new tug should ideally be designed for operations in up to 30 cm of new, fast ice instead of up to 15 cm of fast ice and 30 cm of slush ice as it is now designed. The estimated cost of achieving this would be about $2 million, however, and it is unlikely that there would be time to produce the further-strengthened tug in time for summer, 1986 operations. Analyses presented earlier (sub-section 3.2.7) indicate that the new tug, as currently designed, should be able to maintain operations up to November 15 in most years (about six out of seven) by operating continually as required in heavy ice years to keep fast ice from forming around the wharf and in the exit channel from the harbour. In the occasional year when this might not be possible, limited conventional icebreaker support within the harbour would be called upon to clear the restricted area required for one or two vessels to leave the harbour during the last week of the season. Dredging of the turning area would not be required for such occasional icebreaker operations.

5. This suggests a strategy, therefore, in which the season would be extended as proposed and experience gained under the new extended season, before considering whether or not to strengthen the new tug

further or to make further season extensions (e.g. to July 13 or July 6 in the spring and/or to November 22, November 29 or December 6 in the fall). The operating and cost experience obtained in the 17 week season would provide a much firmer basis than is now available regarding the feasibility of making the additional capital investments and experiencing the additional operating costs required for the longer season extension.

6. Operating experience (particularly in the larger throughput years of 1976 and 1977) and analysis of present operating capability indicate that the rail line, rail/elevator interface, elevator, elevator/vessel interface, and marine operation components of the Churchill grain delivery system have the capability to handle the throughput volumes examined in this study, both in the normal and the proposed extended season, with modest increased capital and operating costs as described in Chapter 7 of the report. This conclusion applies both to the existing delivery system and an improved rail system for operation during the 1990's, under any of the three options for rail improvement (boxcar rehabilitation, use of articulated hopper cars, or refurbishment of the line to carry conventional hopper cars).

7. The new insurance dates agreed to by the London underwriters and already observed by Canadian insurers, correspond to the season limits for marine navigation in the Canadian Arctic under Canada's Arctic Waters Pollution Prevention Act (AWPPA). Under these regulations, type E (unstrengthened) vessels are able to use the Port of Churchill for approximately 98 days per season, between about July 24 and about October 29. Type D vessels (the lowest classification of ice strengthened vessels) are able to use the Port for a season of about 118 days (from about July 12 until about November 6) and type C vessels for about 140 days (between about July 5 and about November 21).

8. There are two ways to address this situation: (1) declare the season open from July 20 to November 15 but only for operation of the various vessel types within the AWPPA limits; or (2) seek to change the AWPPA legislation to allow operation by vessel types E and D up to the limits of the new extended 17 week season but only under stringent conditions of provision of vessel information, use of ice advisors, and icebreaker escort for vessels operating outside of the AWPPA limits.

9. Our conclusion is that the first option is preferable, at least as a first step (e.g. operation of each vessel type within the AWPPA limits up to the limits of the proposed 17 week extended season). This is a logical first step which avoids the problems of a legislative change and an environmental assessment, and which is consistent with dates within which insurance will be available for vessels insured both by London underwriters and Canadian insurers.

10. The above conclusions are based on the premise that the Port of Churchill can and will be operated at viable levels of grain throughput and that appropriate funding and other arrangements would be forthcoming within this policy framework as discussed more fully in Study D.

11. The above conclusions are also drawn in the context of the findings of Study B (e.g. that there are no promising opportunities in sight regarding shipments of additional commodities through Churchill in significant quantities) and Study C (e.g. that an expanded resupply role for Churchill, both for marine and air resupply of Arctic communities, is economically viable and could lead to a doubling of the annual marine resupply shipments through Churchill, from about 16,000-25,000 tonnes per year to about 30-45,000 tonnes per year). If additional commodities were to become economically viable for shipment through the Port in future years (e.g. owing to the establishment of an aluminum smelter in Northern Manitoba, development of a new Arctic mine or oil production, etc.) the additional traffic would be expected to strengthen the conclusions stated above regarding the economic viability of extending the shipping season. Similarly, an extended shipping season would contribute to the ease of operations for expanded Arctic resupply through the Port, and operational conflicts between resupply and grain traffic are not anticipated for the recommended expanded resupply operations.

In summary, there is a good economic case to be made for expanding the existing 12 week shipping season of the Port of Churchill to 17 weeks, with subsequent consideration of possible further expansions based on the experience with the new expanded season. Minimal capital investments would be required to achieve the 17 week season and it is proposed that relevant vessel types would operate within the new season in accordance with AWPPA season limits for Class E and Class D vessels which are somewhat shorter than the 17 week season.

8.2 PROPOSED ACTION PLAN

As noted in Point 10 of the Conclusions section above, the conclusions and recommendations presented here will apply only if there is an appropriate policy framework under which the Port of Churchill continues as a grain export port, at throughput levels which are high enough to be economic. Therefore, the first group of actions required in terms of season extension at the Port of Churchill must include the relevant policy decisions by the Government of Canada and discussions with the Canadian Wheat Board to establish an understanding regarding throughput levels to be used as targets by the CWB. In order to provide the CWB with marketing flexibility, any such targets would remain confidential and should probably be multi-year in nature; the policy statement by the Government of Canada would, of course, be public. The proposed action plan outlined below is based on the premise that export grain will consistently move through the Port at annual levels of about 600,000-700,000 tonnes per year or more.

Owing to the minimal physical and institutional requirements to achieve the proposed 17 week extended season, the action plan is relatively simple, as follows:

1. Representatives of the Government of Canada and the Government of Manitoba should continue discussions with London underwriters and representatives of the Canadian insurance industry in order to secure agreement as quickly as possible on new insurance arrangements for vessels using the Port of Churchill within the AWPPA season limits by type of vessel.

2. Arrangements should be made between Ports Canada and the Canadian Coast Guard for extended operation of the radio stations at Churchill and Frobisher Bay in order to serve the entire 17 week extended season and for standby icebreaker escort service for vessels en route between Churchill and Cape Chidley, in years where required by ice conditions.

3. In addition, arrangements should be made between these two agencies and other parties as appropriate to achieve the following in support of the extended season:

- establishment of an on-going monitoring program to provide year-by-year data on ice conditions in the harbour at Churchill, including ice conditions before freeze-over, date of freeze-over, ice thicknesses to the end of the new extended season and beyond, ice build-up on the dock face, and related weather conditions (it should be noted that this program, which was initiated in fall 1985 as recommended by the study team, can be carried out relatively easily by Ports Canada staff and therefore has little or no incremental cost);

- all vessels using Churchill in the extended season be required to report their positions twice daily to the Coast Guard, cooperate fully with the Ice Information Officer, and make use of the ice advisory service (based on aerial and satellite reconnaissance, ice forecasts, recommended shipping tracks and other relevant information) operated by the Atmospheric Environment Service and the Canadian Coast Guard; this procedure should also be required during the regular season;

- information services provided in the Port of Churchill be improved by providing access to ice charts, telephone contact with the Ice Information Officer to obtain routing advice and ice forecasts, and a formal mechanism for scheduling icebreaker escorts if required during an extended season. This service should also support coastal resupply operations out of the Port of Churchill;

- the regulations regarding the provision of icebreaker escort services should be determined and published by Transport Canada as should the rules to be followed by ships under escort both en route and in the harbour at Churchill;

- a process of monitoring and forecasting ice conditions be developed including two week forecasts of sufficient accuracy to enable icebreaker escort needs to be determined plus the appropriate scheduling of these services, and 4-6 week forecasts with sufficient accuracy to categorize the type of conditions to be expected as either good, moderate or heavy ice conditions;

- suitability of the land based navigational ranges at the Port of Churchill for operations within the harbour during the extended fall season be monitored and assessed, such that the improved land based radar beacons discussed in the report be installed if required; and

- arrangements for flying in skilled personnel and materials from established shipyards in Eastern Canada, as may be required from time to time to carry out vessel repairs that might be required in the Port of Churchill, be formalized..

Underwriters should be made aware of these arrangements.

In addition to this, information links should be established between Ports Canada, the Canadian Coast Guard and the Canadian Wheat Board such that the Coast Guard and the Port are informed in advance of anticipated grain vessel arrivals off Cape Chidley and the Coast Guard is informed of the dates of anticipated vessel departures from the Port, in order that the Coast Guard can ensure that regular radio communications are maintained with vessels en route, that vessel captains are aware of support and advisory services, and that the Coast Guard is in a position to provide icebreaker escort if required.

Finally, as noted earlier, if the extended 17 week season is brought into effect, it is recommended that the operating and cost experience in the extended season be monitored by Ports Canada and other participants such that an assessment can be made subsequently regarding the possible cost-effectiveness of additional season extensions.

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APPENDIX A

ICE COVERAGE EN ROUTE

APPENDIX A

ICE COVERAGE EN ROUTE

APPENDIX A

ICE COVERAGE EN ROUTE

The series of tables in this Appendix present data on the ice conditions which have occurred on the navigation route between Churchill and Cape Chidley in each week during the period July 9th to December 3rd, over the years 1959 through 1983. The data for each week includes the lengths of the route (in nautical miles) which were covered by each of six different types of ice conditions as follows:

Ice Type Condition	Description
A	Open water
B-A	1/10 - 2/10 new ice
C-B	4/10 - 6/10 new ice or 1/10 - 2/10 first year ice
D-C	7/10 - 8/10 new ice or 4/10 - 6/10 first year ice
E-D	9/10 - 10/10 new ice or 7/10 - 8/10 first year ice - ice breaker escort required
E	9/10 - 10/10 first year ice - ice breaker escort required where "new ice" is less than 30 cm thick and "first year ice" is ice over 30 cm thick.

Based on the different assumed sailing speeds corresponding to each type of ice condition, estimates of total sailing time (without ice breaker escort) and total time spent under ice breaker escort are also presented in the tables for each week. Finally, the proportions of the route covered by each type of ice in the best, mode, average, 80th percentile and worst years are given for each week.

TABLE OF ICE COVERAGE IN NAUTICAL MILES

		ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots)						TOTAL ROUTE MILES	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		13	12	10	8	5	3	1150		
WEEK	YEAR	A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
JUL-09	1959									
JUL-09	1960	580		170	130		270	1150	168	106
JUL-09	1961	830		230	60	30		1150	100	14
JUL-09	1962	400		200	410		140	1150	149	98
JUL-09	1963	770		40	50	290		1150	128	64
JUL-09	1964	230		120	270	530		1150	169	140
JUL-09	1965	840		230	80			1150	98	10
JUL-09	1966	660		60	350	80		1150	117	60
JUL-09	1967	760			200	190		1150	122	63
JUL-09	1968	650		190	280	30		1150	110	41
JUL-09	1969	760		130	180	80		1150	110	39
JUL-09	1970	960		170	20			1150	93	3
JUL-09	1971	625		220	150	30	125	1150	137	66
JUL-09	1972	515		190	235	150	60	1150	138	79
JUL-09	1973	835		60	180		75	1150	118	48
JUL-09	1974	550			140	320	140	1150	171	128
JUL-09	1975	445		80	245	30	350	1150	196	153
JUL-09	1976	840		140	80	90		1150	107	28
JUL-09	1977	750		370	30			1150	98	4
JUL-09	1978	570		140	250		190	1150	152	95
JUL-09	1979	755		305	70	10	10	1150	103	14
JUL-09	1980	720		250	130	50		1150	107	26
JUL-09	1981	1030		60	20	40		1150	96	11
JUL-09	1982	895		10	90	80	75	1150	122	52
JUL-09	1983	380		90	300		380	1150	202	164
WORST		380	0	90	300	0	380	1150	202	164.2
80 %		570	0	140	250	0	190	1150	152	94.6
AVERAGE		700	0	138	158	81	73	1150	129	60.2
MODE		835	0	60	180	0	75	1150	118	47.5
BEST		960	0	170	20	0	0	1150	93	2.5

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1983	1978	1973	1970

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots) 13	12	10	8	5	3	TOTAL ROUTE MILES 1150	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
JUL-16	1959	950		190	10			1150	93	1
JUL-16	1960	950		10	130	10	50	1150	109	35
JUL-16	1961	900		130	90	30		1150	100	17
JUL-16	1962	860		180	70	40		1150	101	17
JUL-16	1963	680		160	200	110		1150	115	47
JUL-16	1964	730		200	100	90	30	1150	117	41
JUL-16	1965	1020		130				1150	92	0
JUL-16	1966	830		160	130	30		1150	102	22
JUL-16	1967	670		380	100			1150	102	13
JUL-16	1968	1110		40				1150	89	0
JUL-16	1969	1070		60	20			1150	91	3
JUL-16	1970	1050		100				1150	91	0
JUL-16	1971	810		90	150	100		1150	110	39
JUL-16	1972	520		250	230	60	90	1150	136	71
JUL-16	1973	790		80	260	20		1150	105	37
JUL-16	1974	810		110	70	120	40	1150	119	46
JUL-16	1975	850		90	60	90	60	1150	120	46
JUL-16	1976	880		270				1150	95	0
JUL-16	1977	730		320	100			1150	101	13
JUL-16	1978	850		190	70	40		1150	101	17
JUL-16	1979	970		100	50	30		1150	97	12
JUL-16	1980	970		180				1150	93	0
JUL-16	1981	1090		60				1150	90	0
JUL-16	1982	1130		20				1150	89	0
JUL-16	1983	560			300		290	1150	177	134
	WORST	560	0	0	300	0	290	1150	177	134.2
	80 %	680	0	160	200	110	0	1150	115	47.0
	AVERAGE	871	0	140	86	31	22	1150	105	24.3
	MODE	860	0	180	70	40	0	1150	101	16.8
	BEST	1130	0	20	0	0	0	1150	89	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1983	1963	1962	1982

TABLE OF ICE COVERAGE IN NAUTICAL MILES

		ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots)						TOTAL ROUTE MILES	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		13	12	10	8	5	3	1150		
WEEK	YEAR	A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
JUL-23	1959	970		180				1150	93	0
JUL-23	1960	990		80	30		50	1150	105	20
JUL-23	1961	1090		40	20			1150	90	3
JUL-23	1962	1070		80				1150	90	0
JUL-23	1963	760		210	180			1150	102	23
JUL-23	1964	840		70	240			1150	102	30
JUL-23	1965	1150						1150	89	0
JUL-23	1966	1120		30				1150	89	0
JUL-23	1967	970		110	70			1150	94	9
JUL-23	1968	1080		30		40		1150	94	8
JUL-23	1969	1080		70				1150	90	0
JUL-23	1970	950		200				1150	93	0
JUL-23	1971	1110		30	10			1150	90	1
JUL-23	1972	670		230	110	140		1150	116	42
JUL-23	1973	830		180	120	20		1150	101	19
JUL-23	1974	870		220	20	40		1150	99	11
JUL-23	1975	1050		40	60			1150	92	8
JUL-23	1976	1000		150				1150	92	0
JUL-23	1977	1090		60				1150	90	0
JUL-23	1978	1110		40				1150	89	0
JUL-23	1979	1040		10	100			1150	94	13
JUL-23	1980	1150						1150	89	0
JUL-23	1981	1150						1150	89	0
JUL-23	1982	890		230	30			1150	95	4
JUL-23	1983	770		210	110	60		1150	106	26
	WORST	670	0	230	110	140	0	1150	116	41.8
	80 %	830	0	180	120	20	0	1150	101	19.0
	AVERAGE	992	0	130	44	12	2	1150	95	8.6
	MODE	970	0	180	0	0	0	1150	93	0.0
	BEST	1150	0	0	0	0	0	1150	89	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1972	1973	1959	1981

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots) 13	12	10	8	5	3	TOTAL ROUTE MILES 1150	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
JUL-30	1959	1110				40		1150	93	8
JUL-30	1960	1080		20		20	30	1150	99	14
JUL-30	1961	1120		30				1150	89	0
JUL-30	1962	1150						1150	89	0
JUL-30	1963	930		100	100	20		1150	98	17
JUL-30	1964	1070		80				1150	90	0
JUL-30	1965	1150						1150	89	0
JUL-30	1966	1150						1150	89	0
JUL-30	1967	1150						1150	89	0
JUL-30	1968	1130			20			1150	89	3
JUL-30	1969	1130		20				1150	89	0
JUL-30	1970	1150						1150	89	0
JUL-30	1971	1070			60	20		1150	94	12
JUL-30	1972	830		80	240			1150	102	30
JUL-30	1973	930		220				1150	94	0
JUL-30	1974	1090		20	20	20		1150	92	7
JUL-30	1975	1100			50			1150	91	6
JUL-30	1976	1150						1150	89	0
JUL-30	1977	1150						1150	89	0
JUL-30	1978	1150						1150	89	0
JUL-30	1979	1120		30				1150	89	0
JUL-30	1980	1150						1150	89	0
JUL-30	1981	1150						1150	89	0
JUL-30	1982	1150						1150	89	0
JUL-30	1983	870		170	110			1150	98	14
	WORST	830	0	80	240	0	0	1150	102	30.0
	80 %	930	0	220	0	0	0	1150	94	0.0
	AVERAGE	1089	0	31	24	5	1	1150	91	4.4
	MODE	1120	0	30	0	0	0	1150	89	0.0
	BEST	1150	0	0	0	0	0	1150	89	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1972	1973	1961	1982

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots) A 13	B-A 12	C-B 10	D-C 8	E-D 5	E 3	TOTAL ROUTE MILES 1150 TRM	SAILING TIME (HOURS) ST	ESCORT TIME (HOURS) ET
AUG-06	1959	1150						1150	89	0
AUG-06	1960	1135				15		1150	90	3
AUG-06	1961	1150						1150	89	0
AUG-06	1962	1150						1150	89	0
AUG-06	1963	1140		10				1150	89	0
AUG-06	1964	1150						1150	89	0
AUG-06	1965	1150						1150	89	0
AUG-06	1966	1150						1150	89	0
AUG-06	1967	1150						1150	89	0
AUG-06	1968	1150						1150	89	0
AUG-06	1969	1150						1150	89	0
AUG-06	1970	1150						1150	89	0
AUG-06	1971	1080		40			30	1150	97	10
AUG-06	1972	870		160	105	15		1150	99	16
AUG-06	1973	1010		140				1150	92	0
AUG-06	1974	1150						1150	89	0
AUG-06	1975	1150						1150	89	0
AUG-06	1976	1150						1150	89	0
AUG-06	1977	1150						1150	89	0
AUG-06	1978	1150						1150	89	0
AUG-06	1979	1150						1150	89	0
AUG-06	1980	1150						1150	89	0
AUG-06	1981	1150						1150	89	0
AUG-06	1982	1150						1150	89	0
AUG-06	1983	975		175				1150	93	0
WORST		870	0	160	105	15	0	1150	99	16.1
80 %		1140	0	10	0	0	0	1150	89	0.0
AVERAGE		1122	0	21	4	1	1	1150	90	1.2
MODE		1150	0	0	0	0	0	1150	89	0.0
BEST		1150	0	0	0	0	0	1150	89	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1972	1963	1982	1982

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots) A (13)	B-A (12)	C-B (10)	D-C (8)	E-D (6)	E (4)	TOTAL ROUTE MILES 1070 TRM	SAILING TIME (HOURS) ST	ESCORT TIME (HOURS) ET
OCT-15	1959	1070	0	0	0	0	0	1070	82	0
OCT-15	1960	1070						1070	82	0
OCT-15	1961	1070						1070	82	0
OCT-15	1962	1070						1070	82	0
OCT-15	1963	1070						1070	82	0
OCT-15	1964	1070						1070	82	0
OCT-15	1965	1040			30			1070	84	0
OCT-15	1966	1070						1070	82	0
OCT-15	1967	1070						1070	82	0
OCT-15	1968	1070						1070	82	0
OCT-15	1969	1070						1070	82	0
OCT-15	1970	1070						1070	82	0
OCT-15	1971	1070						1070	82	0
OCT-15	1972	995		75				1070	84	0
OCT-15	1973	1070						1070	82	0
OCT-15	1974	1030		40				1070	83	0
OCT-15	1975	1070						1070	82	0
OCT-15	1976	1070						1070	82	0
OCT-15	1977	1070						1070	82	0
OCT-15	1978	1030		40				1070	83	0
OCT-15	1979	1070						1070	82	0
OCT-15	1980	1070						1070	82	0
OCT-15	1981	1070						1070	82	0
OCT-15	1982	1070						1070	82	0
OCT-15	1983	1070						1070	82	0
	WORST	995	0	75	0	0	0	1070	84	0.0
	80 %	1070	0	0	0	0	0	1070	82	0.0
	AVERAGE	1063	0	6	1	0	0	1070	83	0.0
	MODE	1070	0	0	0	0	0	1070	82	0.0
	BEST	1070	0	0	0	0	0	1070	82	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1972	1983	1983	1983

TABLE OF ICE COVERAGE IN NAUTICAL MILES

		ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots)						TOTAL ROUTE MILES	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		13	12	10	8	6	4	1070		
WEEK	YEAR	A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
OCT-22	1959	1050	0	20	0	0	0	1070	83	0
OCT-22	1960	1070						1070	82	0
OCT-22	1961	1070						1070	82	0
OCT-22	1962	1070						1070	82	0
OCT-22	1963	1070						1070	82	0
OCT-22	1964	1070						1070	82	0
OCT-22	1965	1010		60				1070	84	0
OCT-22	1966	1070						1070	82	0
OCT-22	1967	1070						1070	82	0
OCT-22	1968	1070						1070	82	0
OCT-22	1969	1070						1070	82	0
OCT-22	1970	1070						1070	82	0
OCT-22	1971	1070						1070	82	0
OCT-22	1972	1020		50				1070	83	0
OCT-22	1973	1070						1070	82	0
OCT-22	1974	1060			10			1070	83	0
OCT-22	1975	1070						1070	82	0
OCT-22	1976	1070						1070	82	0
OCT-22	1977	1070						1070	82	0
OCT-22	1978	930		70		70		1070	90	12
OCT-22	1979	1070						1070	82	0
OCT-22	1980	1070						1070	82	0
OCT-22	1981	1070						1070	82	0
OCT-22	1982	1070						1070	82	0
OCT-22	1983	1050	20					1070	82	0
	WORST	930	0	70	0	70	0	1070	90	11.7
	80 %	1050	20	0	0	0	0	1070	82	0.0
	AVERAGE	1058	1	8	0	3	0	1070	83	0.5
	MODE	1070	0	0	0	0	0	1070	82	0.0
	BEST	1070	0	0	0	0	0	1070	82	0.0

	WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
	1978	1983	1982	1982
	1978	1975	1983	

TABLE OF ICE COVERAGE IN NAUTICAL MILES

		ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (Knots)						TOTAL ROUTE MILES	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		13	12	10	8	6	4	1070		
WEEK	YEAR	A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
OCT-29	1959	1070	0	0	0	0	0	1070	82	0
OCT-29	1960	1050			20			1070	83	0
OCT-29	1961	1040	30					1070	83	0
OCT-29	1962	1040		30				1070	83	0
OCT-29	1963	1050			20			1070	83	0
OCT-29	1964	1070						1070	82	0
OCT-29	1965	930	10	30	100			1070	88	0
OCT-29	1966	1070						1070	82	0
OCT-29	1967	1070						1070	82	0
OCT-29	1968	1070						1070	82	0
OCT-29	1969	1070						1070	82	0
OCT-29	1970	1070						1070	82	0
OCT-29	1971	1070						1070	82	0
OCT-29	1972	960		80	30			1070	86	0
OCT-29	1973	1070						1070	82	0
OCT-29	1974	1060	10					1070	82	0
OCT-29	1975	1070						1070	82	0
OCT-29	1976	1070						1070	82	0
OCT-29	1977	1070						1070	82	0
OCT-29	1978	880			150	40		1070	93	7
OCT-29	1979	1070						1070	82	0
OCT-29	1980	1070						1070	82	0
OCT-29	1981	1070						1070	82	0
OCT-29	1982	1070						1070	82	0
OCT-29	1983	1040	30					1070	83	0
WORST		880	0	0	150	40	0	1070	93	6.7
80 %		1040	0	30	0	0	0	1070	83	0.0
AVERAGE		1047	3	6	13	2	0	1070	83	0.3
MODE		1070	0	0	0	0	0	1070	82	0.0
BEST		1070	0	0	0	0	0	1070	82	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1978	1962	1982	1982

TABLE OF ICE COVERAGE IN NAUTICAL MILES

		ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots)						TOTAL ROUTE MILES	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		13	12	10	8	6	4	1070		
WEEK	YEAR	A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
NOV-05	1959	1070	0	0	0	0	0	1070	82	0
NOV-05	1960									
NOV-05	1961	1040		30				1070	83	0
NOV-05	1962	1030	20	20				1070	83	0
NOV-05	1963	1030	10		30			1070	84	0
NOV-05	1964	1070						1070	82	0
NOV-05	1965	820		130	100	20		1070	92	3
NOV-05	1966	1060	10					1070	82	0
NOV-05	1967	995	75					1070	83	0
NOV-05	1968	1070						1070	82	0
NOV-05	1969	1040			30			1070	84	0
NOV-05	1970	1050		20				1070	83	0
NOV-05	1971	1070						1070	82	0
NOV-05	1972	410		315	195	150		1070	112	25
NOV-05	1973	1070						1070	82	0
NOV-05	1974	1050			20			1070	83	0
NOV-05	1975	1070						1070	82	0
NOV-05	1976	990	80					1070	83	0
NOV-05	1977	1070						1070	82	0
NOV-05	1978	820		20	120	110		1070	98	18
NOV-05	1979	1040	30					1070	83	0
NOV-05	1980	1070						1070	82	0
NOV-05	1981	1070						1070	82	0
NOV-05	1982	1070						1070	82	0
NOV-05	1983	1070						1070	82	0
	WORST	410	0	315	195	150	0	1070	112	25.0
	80 %	1050	0	0	20	0	0	1070	83	0.0
	AVERAGE	1006	9	22	21	12	0	1070	85	1.9
	MODE	1060	10	0	0	0	0	1070	82	0.0
	BEST	1070	0	0	0	0	0	1070	82	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1972	1974	1966	1983

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots) A (13)	B-A (12)	C-B (10)	D-C (8)	E-D (6)	E (4)	TOTAL ROUTE MILES TRM (1070)	SAILING TIME (HOURS) ST	ESCORT TIME (HOURS) ET
NOV-12	1959	480	0	90	400	100	0	1070	113	17
NOV-12	1960	900	50	120				1070	85	0
NOV-12	1961	960	80	30				1070	84	0
NOV-12	1962	1040		30				1070	83	0
NOV-12	1963	1050		10	10			1070	83	0
NOV-12	1964	1060		10				1070	83	0
NOV-12	1965	460		240	180	240		1120	122	40
NOV-12	1966	920	30	120				1070	85	0
NOV-12	1967	900	30	20	120			1070	89	0
NOV-12	1968	1055	15					1070	82	0
NOV-12	1969	830		200	40			1070	89	0
NOV-12	1970	1050			10	10		1070	84	2
NOV-12	1971	1040		30				1070	83	0
NOV-12	1972	450		60	560	90		1160	126	15
NOV-12	1973	1070						1070	82	0
NOV-12	1974	930		50	90			1070	88	0
NOV-12	1975	1070						1070	82	0
NOV-12	1976	740	150	180				1070	87	0
NOV-12	1977	1070						1070	82	0
NOV-12	1978	710		70	110	180		1070	105	30
NOV-12	1979	950	90		30			1070	84	0
NOV-12	1980	1020	30		20			1070	83	0
NOV-12	1981	1040	30					1070	83	0
NOV-12	1982	1020			20	50		1090	89	8
NOV-12	1983	830		180	40	20		1070	90	3
WORST		450	0	60	560	90	0	1160	126	40.0
80 %		1020	0	0	20	50	0	1090	89	8.3
AVERAGE		906	20	58	65	28	0	1076	90	4.6
MODE		950	90	0	30	0	0	1070	84	0.0
BEST		1070	0	0	0	0	0	1070	82	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1972	1982	1979	1977

exhibit 7.5

COMPARISON OF MARINE FREIGHT RATES TO ROTTERDAM FROM CHURCHILL AND THUNDER BAY

MARINE FREIGHT MARKET SCENARIO	MARINE FREIGHT RATES ($/TONNE)			MARINE FREIGHT RATES LESS SEAWAY TOLLS ($/TONNE)	
	VIA CHURCHILL	VIA THUNDER BAY	VIA THUNDER BAY & ST. LAWRENCE PORT	VIA * THUNDER BAY	VIA THUNDER BAY & ** ST. LAWRENCE PORT
LOW	$15.30	$22.23	$32.20	$20.85	$31.02
MEDIUM	$23.20	$37.33	$35.70	$35.95	$34.52
HIGH	$39.40	$49.83	$45.10	$48.45	$43.92

* Excludes estimated $1.38/tonne in SLSA tolls which would not be saved by system through a transfer to the Churchill route.

** Excludes estimated $1.18/tonne in SLSA tolls which would not be saved by system through a transfer to the Churchill route.

Source: Port of Churchill - Grain Shipping Costs, Study D.

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (Knots) 13	12	10	8	6	4	TOTAL ROUTE MILES 1070	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
NOV-19	1959									
NOV-19	1960	850		140	50	30		1070	91	5
NOV-19	1961									
NOV-19	1962									
NOV-19	1963	960	90	20				1070	83	0
NOV-19	1964	1050		10	10			1070	83	0
NOV-19	1965	90	120	90	50	720		1070	152	120
NOV-19	1966	690	90	120	50	120		1070	99	20
NOV-19	1967	640	10	260	160			1070	96	0
NOV-19	1968	1050		20				1070	83	0
NOV-19	1969	330		400	360			1090	110	0
NOV-19	1970	1030		10	30			1070	84	0
NOV-19	1971	1050			20			1070	83	0
NOV-19	1972	120	30		330	590		1070	151	98
NOV-19	1973	1040			30			1070	84	0
NOV-19	1974	840			230			1070	93	0
NOV-19	1975	1060				10		1070	83	2
NOV-19	1976	620		240	230			1090	100	0
NOV-19	1977	1030		40				1070	83	0
NOV-19	1978	270	150	30	30	590		1070	138	98
NOV-19	1979	930		60	30	50		1070	90	8
NOV-19	1980	860	120	30	60			1070	87	0
NOV-19	1981	1000	50	20				1070	83	0
NOV-19	1982	520		130	280	150		1080	113	25
NOV-19	1983	480	30	260	200	150		1120	115	25
	WORST	90	120	90	50	720	0	1070	152	120.0
	80 %	330	0	400	360	0	0	1090	110	0.0
	AVERAGE	750	31	85	98	110	0	1075	99	18.3
	MODE	860	120	30	60	0	0	1070	87	0.0
	BEST	1050	0	10	10	0	0	1070	83	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1965	1969	1980	1964

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (knots) 13	12	10	8	6	4	TOTAL ROUTE MILES 1100	SAILING TIME (HOURS)	ESCORT TIME (HOURS)
		A	B-A	C-B	D-C	E-D	E	TRM	ST	ET
NOV-26	1959									
NOV-26	1960									
NOV-26	1961									
NOV-26	1962									
NOV-26	1963									
NOV-26	1964	960			80	60		1100	94	10
NOV-26	1965	120		270		710		1100	155	118
NOV-26	1966	660			50	390		1100	122	65
NOV-26	1967	470		60	180	390		1100	130	65
NOV-26	1968	1080			20			1100	86	0
NOV-26	1969	150		100	700	150		1100	134	25
NOV-26	1970	770		300	30			1100	93	0
NOV-26	1971	670		300	90	40		1100	99	7
NOV-26	1972	70		130	150	750		1100	162	125
NOV-26	1973	1070			30			1100	86	0
NOV-26	1974	480		250	40	330		1100	122	55
NOV-26	1975	1050			20	30		1100	88	5
NOV-26	1976	360		120	590	30		1100	118	5
NOV-26	1977	1050		20	30			1100	87	0
NOV-26	1978	60		80	300	100	560	1100	207	157
NOV-26	1979	920			70	110		1100	98	18
NOV-26	1980	1020		50		30		1100	88	5
NOV-26	1981	970		100	30			1100	88	0
NOV-26	1982	195		30	95	280	500	1100	202	172
NOV-26	1983	30			710	360		1100	151	60
	WORST	60	0	80	300	100	560	1100	207	171.7
	80 %	30	0	0	710	360	0	1100	151	60.0
	AVERAGE	608	0	91	161	188	53	1100	120	44.6
	MODE	670	0	300	90	40	0	1100	99	6.7
	BEST	1080	0	0	20	0	0	1100	86	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1978	1983	1971	1968

TABLE OF ICE COVERAGE IN NAUTICAL MILES

WEEK	YEAR	ASSUMED SAILING SPEED FOR DIFFERENT ICE COVERAGE (Knots) 13 A	12 B-A	10 C-B	8 D-C	6 E-D	4 E	TOTAL ROUTE MILES 1100 TRM	SAILING TIME (HOURS) ST	ESCORT TIME (HOURS) ET
DEC-03	1959									
DEC-03	1960									
DEC-03	1961									
DEC-03	1962									
DEC-03	1963									
DEC-03	1964									
DEC-03	1965									
DEC-03	1966									
DEC-03	1967									
DEC-03	1968	1020			20	60		1100	91	10
DEC-03	1969									
DEC-03	1970	150				950		1100	170	158
DEC-03	1971									
DEC-03	1972									
DEC-03	1973	150				670	280	1100	193	182
DEC-03	1974									
DEC-03	1975	710			300	90		1100	107	15
DEC-03	1976	150		120	30	800		1100	161	133
DEC-03	1977	170		190	560	180		1100	132	30
DEC-03	1978	0		30	120	210	740	1100	238	220
DEC-03	1979	220		180	410	170	120	1100	145	58
DEC-03	1980	120			360	150	470	1100	197	143
DEC-03	1981	560		30	510			1100	110	0
DEC-03	1982	10		360	70	660		1100	156	110
DEC-03	1983	0		30		470	600	1100	231	228
WORST		0	0	30	120	210	740	1100	238	228.3
80 %		120	0	0	360	150	470	1100	197	142.5
AVERAGE		272	0	78	198	368	184	1100	161	107.3
MODE		10	0	360	70	660	0	1100	156	110.0
BEST		1020	0	0	20	60	0	1100	91	0.0

WORST YEAR	80 % YEAR	MODE YEAR	BEST YEAR
1978	1980	1982	1968

APPENDIX B

PORT RELATED EMPLOYMENT

APPENDIX B

PORT RELATED EMPLOYMENT

BACKGROUND

Ports Canada employs substantially all the personnel required for operating the grain elevator system and the harbour services at the Port of Churchill. The operation is almost completely self-contained, although significant purchase of professional and construction services in varying amounts are made each year.

In addition to servicing its own operation, the Port management provides contracted stevedoring services to deep sea shipping companies and support services to the Northern Transportation Company Ltd (NTCL).

Typically, during peak periods approximately 150 persons have been employed at Churchill by Ports Canada of which approximately 20 are office staff, 8 are stevedores and 57 are employed in the elevator. The remainder are employed on the two tugs, the machine shop and other areas of the Port.

Approximately two-thirds of the peak season staff are brought in from outside. In order to obtain the required quality of staff, personnel are hired with the expectation of minimum seasonal pay including straight time and overtime working. This factor coupled with the fact that staff must usually be hired before elevator shipments for the year are known results in significant periodic overstaffing in years having low throughputs (e.g. less than 500,000 tonnes per year).

Labour productivity is not particularly sensitive to variation in seasonal levels of output since peak grain delivery and vessel loading rates rather than average grain throughput rates determine manpower requirements. Consequently, if the facility is to achieve high levels of productivity, it must continuously operate at or near its rated capacity

over the entire ("normal" or extended) season. Some improvement in staff utilization could be achieved if a greater proportion of the work force were local residents.

The availability of resident employees will not likely significantly increase unless alternative employment can be provided in the grain off-season. The principal reason for this is that Churchill is considered by many to be an undesirable place of residence partly because of its isolation and climate and also because of the related high cost of living.

The following data illustrates the latter point:

Post	Environmental Allowance	Living Cost Differential	Fuel & Utilities Differential	Total
Churchill	$ 3,179	$ 1,576	$ 2,125	$ 6,879
Baker Lake	4,429	6,040	5,375	15,844
Rankin Inlet	3,179	4,990	5,125	13,294
Hay River	1,543	1,576	4,625	7,744
The Pas	1,543	---	875	2,418
Whitehorse	1,234	1,576	1,125	3,935
Flin Flon	1,534	---	875	2,418
Tuktoyaktuk	4,429	6,040	7,375	17,844

Base Equipment

For the purpose of estimating economic benefits due to Port employment, Ports Canada staff only were considered. These employees include supervisory staff, elevator staff, stevedores and other Port categories.

Two major categories of employment not considered were NTCL staff and employees of forwarding firms. This employment is directly related to resupply operations and these would not be significantly affected by season extension.

Three major categories which were excluded were Coast Guard and Government of Canada staff associated with ship inspections and enforcement of shipping regulations, Canadian National Railways employees and employees in private firms in the Churchill area or elsewhere who provide services to the Port. The costs and revenues associated with the direct service employment are however accounted for in cost/revenue analyses.

The base employment was estimated by examining the employment records for two years: those for 1977, a record year in terms of grain throughput at the Port and those for 1984, the most recent year for which complete data were available. The data are shown on Exhibit B.1 and clearly indicate the relative inelasticity of employment levels to changes in throughput levels.

The employment associated with the selected grain flow rates of 65,000 tonnes, 75,000 and 85,000 tonnes weekly, were obtained by linear extrapolation and interpolation of the actual employee requirements for throughputs of 37,000 and 70,000 tonnes weekly. The selected basic distribution profile was based on the 70,000 tonnes throughput data since it represented operations closer to capacity. The major variation in the 1977 and 1984 distributions was that there was a significant drop in employment in October 1984. This was attributable to a drop in grain exports in the late part of the 1984 season.

Impact on Employment Duration

Employment at Churchill falls into two general categories, full term employment (10-12 months) and seasonal or short-term employment

EXHIBIT B.1

MONTHLY DISTRIBUTION
TOTAL PORT EMPLOYMENT
REGULAR SEASON

Item	Actual Employment 1977	Actual Employment 1984	Estimated Employment		
Weekly Tonnage	70,000	37,000	65,000	75,000	85,000
January	41	36	41	41	42
February	43	37	43	43	43
March	42	35	42	42	43
April	48	49	48	49	50
May	81	93	80	83	85
June	107	112	105	111	116
July	123	131	121	127	132
August (peak)	152	133	149	156	161
September	144	130	141	148	153
October	132	43	130	136	140
November	78	38	75	76	79
December	41	37	41	41	41
Average Monthly	86	73	85	88	91

* Source: Port of Churchill data.

(9 months or less). Approximately 25 percent of all employees have been considered to be full term. Seasonal employment commences in May, three months prior to season opening and ends in November. The peak employment months are August and September when employment levels reach approximately 150, of which 110 are seasonal.

The impact of season extension would be to increase the duration of the peak employment period by an amount equal to the extension of the season. Employment in the shoulder months will probably continue to have the same distribution as at present, but will shift in time to reflect the change in season opening and closing dates. This assumption is believed to be valid except if the season were extended into late November or early December. In this case the employment drop-off at the close of the season would be sharper because of the influence of the December and year-end holidays

The estimated increase of employment duration by monthly increments is shown Exhibit B.2. Season extension to 20 weeks could increase full time employment at the Port to 50 from 42 persons under base case throughput conditions.

Impact on Churchill Population

At present, approximately one-third of the seasonal employees are full time residents of Churchill. Lengthening the shipping season will increase the average length of time spent in the locality by the remaining employees. This increase in length of stay will increase the tendency for a greater proportion of employees to make their homes in Churchill. An estimate of the effect of this trend was made by the use of a diversion curve which as an upper limit assumed that up to 75 percent of personnel spending nine months in this area would establish a home there, and as a lower limit assumed that no employees employed for one month only would do so. A quadratic curve was fitted to these points by trial and error to

EXHIBIT B.2

ESTIMATED DURATION OF EMPLOYMENT
PORT CHURCHILL
FOR 12, 16 AND 20 WEEK SEASONS

Employment Duration Months	65,000 Tonnes Weekly Throughput			75,000 Tonnes Weekly Throughput			85,000 Tonnes Weekly Throughput		
	12 wks.	16 wks.	20 wks.	12 wks.	16 wks.	20 wks.	12 wks.	16 wks.	20 wks.
10-12	42	43	49	42	43	49	43	43	50
9	1	6	26	1	6	27	0	7	29
8	6	26	7	6	27	7	7	29	6
7	26	7	28	27	7	28	29	6	31
6	7	28	15	7	28	16	6	31	16
5	28	15	10	28	16	9	31	16	8
4	15	10	12	16	9	12	16	8	13
3	10	12	8	9	12	8	8	13	8
2	12	8	0	12	8	0	13	8	0
1	8	0	0	8	0	0	8	0	0

simulate the one-third full time residency rate currently being experienced. The resulting distribution curve was then applied to the data in Exhibit B.2 to produce Exhibit B.3 which is an estimate of the number of permanent residents associated with season extensions from 12 to 16 and 20 weeks for each of the three selected weekly grain throughput rates.

The estimated increased residencies are summarized as follows:

	Additional Residents Above Those for 12 Week Season	
Throughput	4 Week Extension	8 Week Extension
65,000 tonnes	11	25
75,000 tonnes	12	29
85,000 tonnes	11	28
Average	11	27

On average, each week of season extension would result in an estimated 3 additional permanent residents in Churchill. These estimates would change dramatically either if living costs were to fall significantly or if part time employment could be provided to Port employees outside the shipping season.

EXHIBIT B.3

ESTIMATE OF CHURCHILL RESIDENT PORT EMPLOYMENT
12, 16 AND 20 WEEK SEASONS

Employment Duration in Months	Percent Churchill Residencies	65,000 Tonne Weekly Throughput			75,000 Tonne Weekly Throughput			85,000 Tonne Weekly Throughput		
		12 weeks	16 weeks	20 weeks	12 weeks	16 weeks	20 weeks	12 weeks	16 weeks	20 weeks
10 - 12	100	42	43	49	42	43	49	43	43	50
9	75	1	4	19	1	4	21	0	5	22
8	55	3	14	4	3	15	4	4	16	4
7	40	10	3	11	10	3	12	12	3	12
6	30	2	8	4	2	8	5	2	9	5
5	22	6	4	2	6	4	2	7	4	2
4	14	2	1	2	2	1	2	2	1	1
3	8	1	1	1	1	1	1	1	1	1
2	3	0	-	-	0	0	0	0	0	0
1	0	0	-	-	0	0	0	0	0	0
TOTAL CHURCHILL RESIDENTS		67	78	92	67	79	96	71	82	99

APPENDIX C

PORT INVENTORY
PORT OF CHURCHILLL

APPENDIX C

PORT OF CHURCHILL

1. Navigation

Navigation aids are the responsibility of the Canadian Coast Guard; the marine-side facilities are maintained by Ports Canada on a cost recovery basis.

A lighted fairway buoy, fitted with a bell and radar reflector, is positioned 7.0 kilometres northeast of the harbour entrance. The entrance and fairway through the harbour and the turning basin are marked by lighted buoys. The shoal 0.2, miles NNW of Cape Merry, is marked by a similar buoy as well as a bell.

Three sets of light ranges are located onshore on the west side of the river to facilitate entering the harbour.

Pilotage is compulsory for merchant ships entering or shifting berth in the harbour. In general, the pilot is transferred near the fairway buoy from the harbour tug, the W.N. Twolan. Helicopter transfer is available for late season pilotage, as was required by the M.V. Arctic.

There is a small anchorage within the harbour but it is recommended that large vessels anchor one to three miles northwest to northeast of the fairway buoy.

The Canadian Hydrographic Service Sailing directions report that there are three marine/air radio beacons at Churchill. The most powerful is located 12 kilometres east of the harbour; the second is close to the east of the harbour, and the third lies 9.6 kilometres SSW of the first.

2. Harbour

Exhibit C-1 shows the overall layout of the harbour and Port, with dimensions and depths in feet, while Exhibit C-2 shows the existing berths, buildings, railway trackage and related features of the Port in greater detail (measurements in metres).

The harbour entrance channel northwest of Cape Merry has a low water depth up to 21 metres and a width of approximately 840 metres at high tide; this area is subjected to high tidal currents; the flood tidal stream has a rate of about 2 knots. The ebb flow attains a rate of 5 knots. Further upstream the river widens substantially. At a point just south of the main wharf the river is 2.4km wide and a maximum depth of about 4.3 metres. The navigation channel width varies from 350m at the entrance to 200m just north of the main wharf. A major dredging program was completed in 1980, providing a minimum draft of

exhibit C-1

PORT OF CHURCHILL HYDROGRAPHIC CHART
(DEPTH SHOWN IN FEET)

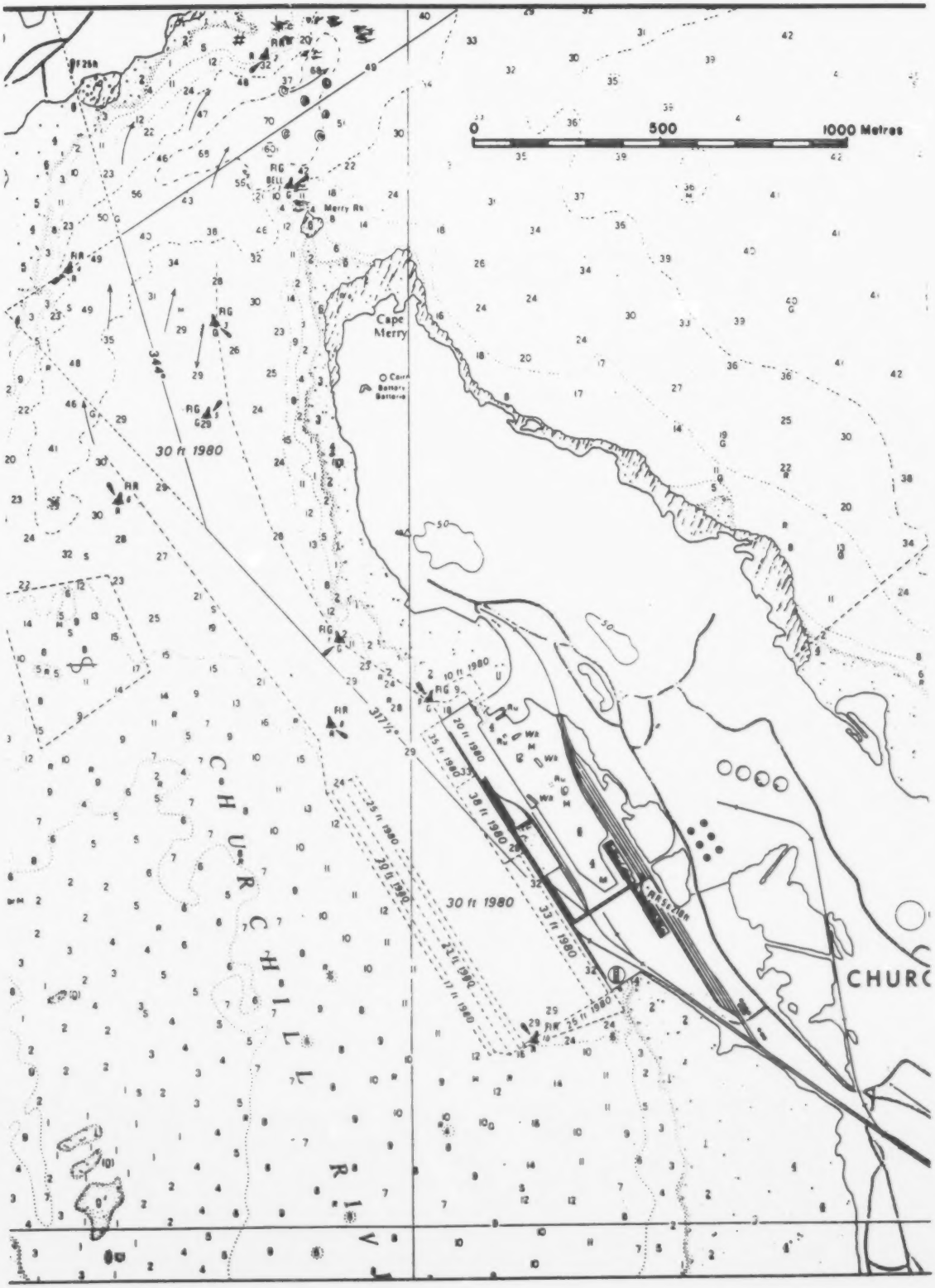
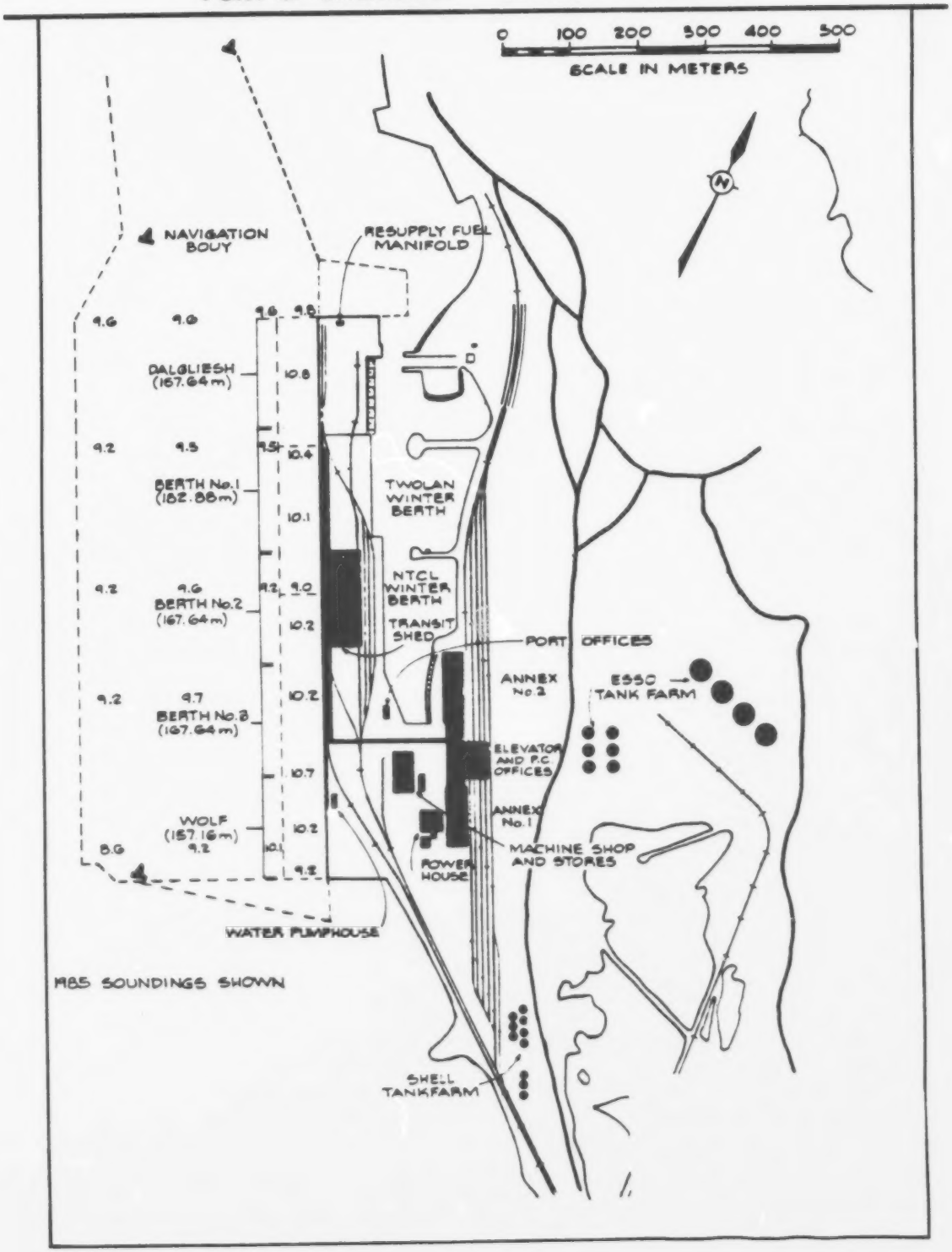


exhibit C-2

PORT OF CHURCHILL - EXISTING CONDITIONS



9.2 metres at low tide. An annual sounding surveying program is being carried out as part of a sedimentation study by a Vancouver consultant studying the effects of the river diversion. The berths alongside the loading gallery were also dredged to provide additinal draft, such that the topping up of vessels can be accomplished at any tide so that a vessel is not restricted to complete loading and leave the harbour on the same high tide.

The recent sounding survey however indicates sedimentation has taken place and this operation is no longer possible for the deeper draft vessels.

The 1980 charted dredge depths are as follows:

The 168m general cargo berth at the north end of the wharf was dredged to 10.6m; 240 metres of the grain loading berths just south of the north general cargo berth was dredged to 11.6m; the remaining length of wharf was dredged to 10.0m, with a narrow band of dredging adjacent to the wharf face 10 metres wide dredged to a depth of between 8.5 to 9.8 metres. The berm against the timber crib wharf was created to ensure against undermining. The original 1980 dredging program was to dredge this area down to 11.6 metres. However, during the dredging program it was discovered that this would undermine this portion of the wharf.

The berths are as follows as of 1985: one 168m general cargo berth with a minimum depth of 9.5m alongside; three grain loading berths totalling 518m, with 9.0m to 9.8m depths alongside, and at the south end of the wharf a general cargo berth 157m long with a depth alongside of 9.0m.

At the north end of the wharf a 93m berth is provided for the resupply barges. Water depth at low tide alongside is 5.5m. The south face of the wharf is used primarily for berthing the small harbour tug, the George Kydd. The actual berth length is approximately 34m and the water depth decreases rapidly towards shore. At the north end of the wharf a slip is provided on the east face, between the wharf and shore north of the elevators and Annex 2. The slipway is approximately 34m wide at the entrance between the wharf wall and old marine railway pier, and runs 600m south to the gallery conveyor causeway. The water depth varies from approximately -2m to +1m[1] at the south end. The portion of the wharf adjacent to the pier shed is used for the resupply barge loading operation and the reaches further south are used for winter berths for the NTCL tug and barges in the south basin and for the harbour tug in the outer basin.

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1 Depths quoted are at Low Water Ordinary Spring tide (LWOST) which is also the Chart Datum.

The winter berths are formed between the wharf and shore in the slip north of the conveyor causeway. The inner basin or berth is formed by an earth dike extending from shore across to the wharf just north of the transit shed, the south end being sealed by the causeway. The berth is approximately 260m long, along the wharf wall and 110m wide along the dike. An access road to the basin bottom is located on the east or shore side of the basin. In 1978 concrete pads and pedestals were constructed on the basin bottom to facilitate repair work and inspection of the barges and tug as required. The dike is fitted with a culvert and gate to empty the basin, a small amount of water is usually in the basin over the winter (largely due to seepage) and a yearly operation to break the vessels from the ice is required in the spring using backhoes and other equipment.

The outer basin is formed between the dike for the inner basin and another earth dike opening the slip at the north end of the old wharf some 150m further north.

The depth of the basin is approximately 0m and accommodates the harbour tug, the Twolan, by tying up along the wharf. The Twolan which has a round bottom, common with seagoing tugs, is not free standing and must winter tied to the wharf.

3. Wharf

The main wharf is owned by Ports Canada and is used by Ports Canada and Northern Transportation Company Limited. Other space is leased to temporary or seasonal operations and shippers as necessary.

The original or old wharf was constructed in 1929-1930 after the rail line to Churchill was constructed in 1928. The wharf was originally 518m long and in 1961 was extended at the north and south ends 168m and 157m respectively for handling general and other cargos.

The wharf is constructed of rock ballasted timber cribs and on the breasting face the cribs are 14.9m wide at the base by either 30.5 or 47m in length by 17m high. The timber cribs are constructed of 300 x 300mm treated B.C. Fir and on the front or berthing face an additional layer of timber is placed against the timber cribs, providing a double wall. Another layer of timber planking is secured to the face, providing additional wear protection. These planks are annually repaired or replaced because of ice damage. The berthing face is also sloped 12:1 and a timber curb is located on the top edge of the cribwork.

A second series of timber cribs is located on the inside edge of the wharf north of the conveyor causeway. These cribs are somewhat smaller than the face cribwork. They vary from 7.3m to 9.8m in width and are 30.5m long and built to a height of 5.8m.

A 116m section of the wall on the east side of the wharf just north of the "old wharf" consists of a rubble embankment.

This area between the two rows of timber cribs originally constructed was gradually filled with gravel and fill over the next following years after construction.

The wharf has an overall length of 843m with a width of 91m at the north end. There is water access on all four sides of the structure, providing the following berthing arrangements, as previously stated: on the west face are three grain berths, Berths No. 1, No. 2 and No. 3, and two general or bulk cargo berths, Dalgliesh at the north end and Wolf at the south. The north face is usually used by the resupply barges for loading bulk fuels; the east face behind the wharf is used for loading the resupply barges as well as being used for the winter berths; the south face is used for berthing smaller tugs and work boats.

The southern 230 metre portion of the wharf is connected to shore and the elevator by an earthen approach or causeway. This approach is used for all access to the wharf and is traversed by rail line, roadways and grain conveyor from the elevator.

The elevator machine shop and power house and the Arctic Grain Company pelletizing plant are also located on the causeway. The roads and rail line run the length of the wharf and off the southeast corner towards the town of Churchill. Other buildings on the wharf are the transit shed, water pumphouse which is at the south end of the wharf, and a small office complex for the various operations and officials of the port.

4. Adjacent Areas

The area north of the wharf is the peninsula with Cape Merry at its northern tip.

The land immediately north of the wharf is owned by Ports Canada and the main portion of Cape Merry Peninsula north of the Ports Canada property is owned by Parks Canada and contains some historic monuments.

The waterway immediately north of the wharf is used primarily by the resupply barges for receiving fuel. The channel is 74 metres wide and the south half of the channel was dredged to 6m and the remainder to 3m in 1980.

North of the channel is an area of tidal flats rising up a sandy beach towards shore. The flood area respresents an area of 5.2 hectares, running north 315 metres from the wharf end to the Cape Merry Peninsula, and east from the wharf face projection to the rail lines. This represents reclaimable land adjacent to the north of the wharf, excluding the channel and winter berths. The water depth ranges from 0 to 7 metres above LWOST.

The area south of the Churchill wharf consists of tidal flats, increasing in width from about 20 metres at the south end of the wharf to a 48 metres width and unlimited length along the east shore of the Churchill River. The area is bounded on the east by the railway tracks and townsite further south.

The available area within 500 metres of the wharf is about 9 hectares but could conceivably extend up to 70 hectares if it were possible to include all the tidal flats area 1.5km south of the wharf. The depth varies from 0 to 6m above LWOST at the rail lines on the east edge of the site.

5. Wharf Facilities

The wharf has a surface area of 7.26 hectares, of which there is approximately 4.0 hectares available for open storage, the main area being to the north of the transit shed.

The wharf is traversed by two groups of rail tracks running from the south - one group up the main wharf face under the loading gallery and the other set running by the east side and also into the transit shed, and continuing almost to the north end of the wharf. The rail lines are in poor to fair condition. The apparently unused line, running along the wharf west edge, is in very poor condition.

The majority of the wharf and approaches are gravel surfaced and there is one loading-unloading ramp for rail cars located outside, north of the transit shed.

The wharf area is supplied with 550 volt power and is well lighted for night work with high level, high pressure sodium lights recently installed.

Two waterlines, 400mm diameter and 457mm diamater respectively, run across the south end of the wharf from the elevator powerhouse to a pumphouse at the south end of the wharf to supply vessels with fresh water.

Fuel and petroleum products for resupply are transferred via a series of pipelines running from the Esso tank farm east of the elevators along the railway berm, then underground to the south end of the wharf, up the east face and across the wharf to an underground header, at about midway across the wharf on the north face. There are two 100mm and one 150mm pipelines serving the dock at this time. It is noted, however, that the facility is not equipped to receive product but could be with minor changes.

Vessels are usually refueled from tanker truck at the southern end of the wharf. Only diesel fuel is available for bunkering; there is no supply of the heavy fuels for ocean-going vessels.

6. Transit Shed Covered Storage

A steel framed and clad transit shed is located midway along the wharf. It provides approximately 7,973 square metres of covered storage, of which some 5,574 square metres are divided and leased to the resupply operator. The facility is lighted but not heated or insulated, and is equipped with a new sprinkler system. A rail spur enters the shed from the south and runs the length of the shed along the east wall. Box cars are unloaded directly from the door level floor inside the shed. The resupply operator has installed their own shrink rap machines, repair shop, etc. Access to the wharf is through either end of the shed. The shed is well maintained and in relatively good condition.

7. Repair Facilities

A complete machine shop is located on the causeway to the wharf, which is used primarily to service the elevator equipment. All the facilities are available for marine work and repair and have been used quite extensively. In fact, the port aluminum work boat was fabricated here. Some of the available equipment includes: MIG welder; full range of electric arc and oxtactelyne welding and cutting equipment; full range of machining equipment - lathe, milling machine, presses, etc.; a 5mm plate bender, as well as a small quantity of light steel plate in stores.

Ports Canada staff report that, for all the vessels arriving at the Port that have suffered ice damage over the years the repairs, although only temporary, have always been sufficient to allow the vessel to take on its load of grain and depart.

8. Grain Facilities

The grain handling facilities consist of a track shed which handles and receives grain via four sets of tracks entering from the north which serve four car dumpers and two hopper car bins, discharging to four sets of receiving scales and conveyors running to the elevator workhouse. Grain is received at a rate of 1,225 tonnes per hour (45,000 bushels). The main terminal facilities consist of a workhouse and two storage annexes with 100 bins. After weighing by car load lots, the grain is elevated and conveyed to bins serving the cleaners or to storage bins for later cleaning. After the grain is cleaned, it is conveyed to one or more of the twelve bins serving the outgoing weighing hoppers, or is conveyed to storage bins for later shipment. The cleaning capacity is 850 tonnes per hour. From the weighing hoppers the grain is fed to one of the four conveyor belts, which deliver grain to the spouts on the gallery. The dock is served via a four-belt conveyor system running from the elevator across the causeway to the loading gallery on the west face of the wharf. The gallery spans the length of the original 1931 wharf and has 23 loading

spouts serving the three main berths. The shipping capacity is 1,633 tonnes per hour (60,000 bushels) from the four conveyors.[2]

9. Petroleum Products

Esso maintains a terminal which is the only significant shipper of petroleum products over the wharf. The other oil Company presently in town is Shell, which competes with Esso for the local fuel requirements and, on the marine side, fueling tugs and resupply vessels. Esso owns and operates the tank farm which is located immeditely east of the elevator on about 10.5 hectares leased from Ports Canada.

At the present time, all product is received by rail but in the past, prior to 1980, overseas oil was received. Now the use of the harbour is limited to resupply shipments for the Keewatin Ports and diesel bunkering. The supply lines to the dock are two 100mm lines and one 150mm line running north of the elevator and to an underground header at the north end of the wharf about mid-way across the wharf. Bunkering is done by tank truck directly to the wharf.

The tank farm facilities include four diesel storage tanks with a capacity of 40,000,000 litres; three gasoline tanks with total storage of 4,000,000 litres; one diesel (dyed) storage tank of 2,300,000 litres, and one tank for Turbo B with a capacity of 1,430,000 litres. There were four large 200mm lines running to the wharf face that were used to receive and ship product but these have since been removed. In 1985 about 20,000,000 litres of product will be shipped.

10. Port Equipment

Vessel handling and cargo handling equipment at the port includes:

Floating Plant

(a) The tug "W.N. Twolan", built in 1962 in Lauzon, Quebec, 29 metres long and 299 gross tons, twin screw, single rudder, equipped with two 760 HP diesel engines, two fire- fighting monitors, ice reinforced hull for ocean travel and accommodation for 8 crew.

(b) The tug "George Kydd", built in 1960 in Owen Sound, Ontario, 13.1 metres long, steel hull at 21 gross tonnage, 600 HP diesel engine for harbour use only.

(c) A new 6 metre aluminum boat , with 110 HP outboard motor, used for sounding work.

(d) A twelve-section flexi float assembly barge, total size 9.1 metres x 39.6 metres.

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2 Grain Movements Through the Port of Churchill in 1976, Canada Grains Council, 1982.

Onshore Equipment:

(a) A 90 tonne crawler crane with 36-metre boom and 9-metre jib boom, complete with attachments and drum laggings for crane, clam and drag work. A 90-tonne hook block is included although taper tip boom is maximum rated at 69.8 tonnes.

(b) One Dominion 550, 31-tonne crawler crane with 24-metre boom, complete with attachments and buckets for crane, clam and drag work.

(c) Two gas powered Plymouth locomotives used for rail switching throughout the area.

(d) One 5-ton truck; 9 1/2-ton trucks.

(e) One Ford 4-ton platform with Pittman hoist.

(f) One portable 20 HP high pressure boiler on wheels.

In addition to this, the resupply operator, NTCL, has its own equipment, which includes:

2 truck tractors
4 highboy trailers
3 950 Cat 8-tonne forklifts
1 966 Cat 9-tonne forklift
1 910 Cat 4-tonne forklift
7 small Hyster forklifts
1 5-ton Hyster forklift

Other equipment from the local municipalities is available, including several loaders, 3 D7 dozers, 1 D5, 2 crawler backhoes, boom truck.